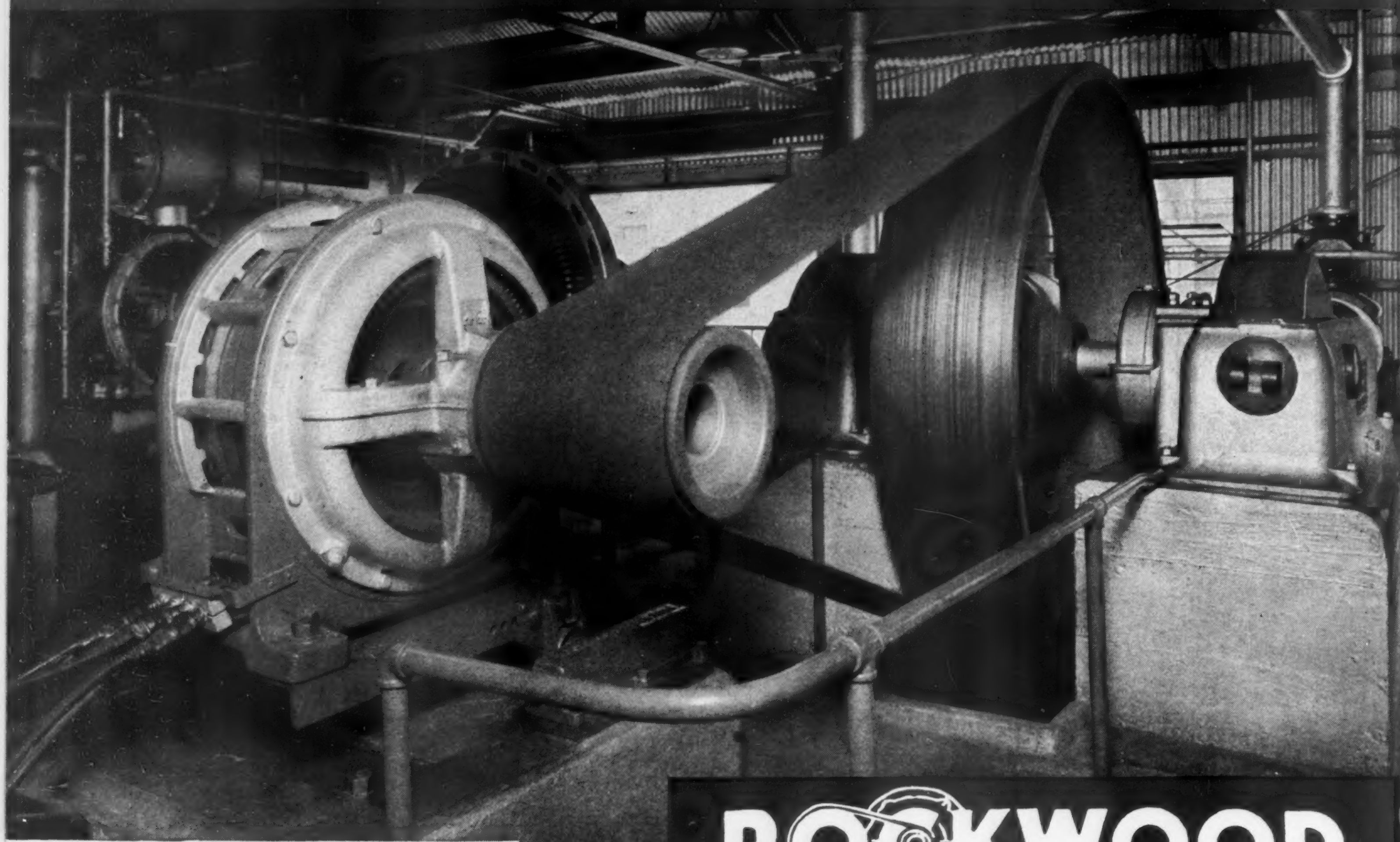
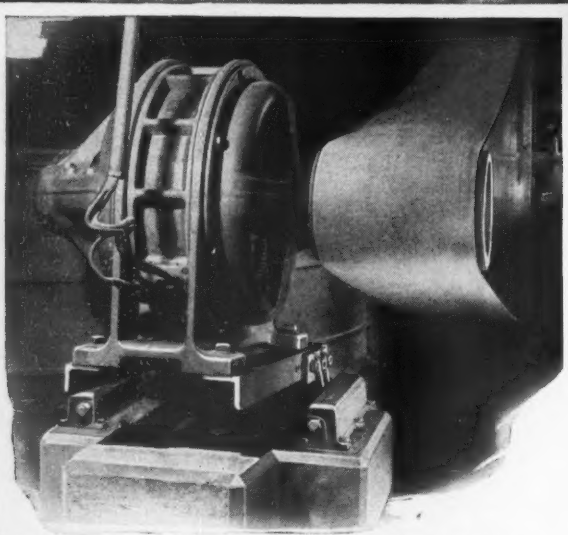
# Compressed Air Magazine

Vol. 43, No. 3 London - New York - Paris March, 1938

REPAIRING CONCRETE LINING OF A TUNNEL

# *Rockwood Drives are reducing maintenance, saving power and improving performance wherever used*





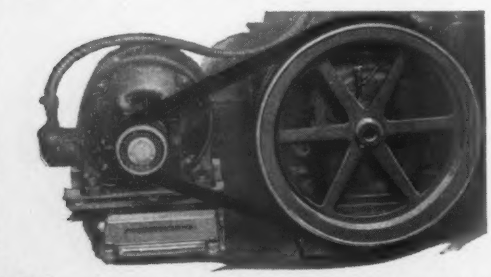
UPPER:—100 h.p. G.E. mctor with Rockwood Drive to Ingersoll-Rand air compressor, Todd Dry Dock Company, Galveston, Texas. See how the weight of the motor, lightly cradled in the belt is used to maintain uniform belt tension. LOWER:—Rockwood Drive, 75 h.p., 600 r.p.m. motor driving beater, Franklin Board & Paper Co. Franklin, Ohio. The Rockwood Drive excells on hard drives.

**ROCKWOOD PIVOTED MOTOR DRIVE**

## *Compressors have more capacity and operate dependably with less attention*

SIXTY thousand installations totaling more than 850,000 h.p. thoroughly demonstrate that the *pivoted motor drive* is a *more satisfactory* installation *for most short center motor drives.* Large numbers of engineers and plant heads agree that the Rockwood Drive for the first time makes short center belt drives *truly* satisfactory. In no other class of service is this more apparent than with belt driven compressors.

Rockwood short center drives consistently give increased compressor capacity, reduced power costs and utter freedom from the bother and expense of drive take ups. The Rockwood Drive *is its own maintenance man.* Once installed it provides dependable performance day after day—month after month—with scarcely a moment's attention. The *first cost is usually less* than for other drives. The upkeep expense is *definitely lower.*



A Rockwood pivoted motor base when used with V-belt drives doubles the life of the belts and improves driven machine performance. Leading automobile manufacturers install Rockwood bases with all new V-belt drives.

### ROCKWOODS TRIAL DRIVE OFFER

Rockwood engineers will supply a complete drive for any accredited company to try out—*for any reasonable period* AND LET THE USER BE THE SOLE JUDGE WHETHER IT GIVES SATISFACTORY OPERATION. The user cannot lose—Rockwood takes all the chances. PICK OUT A HARD DRIVE and write us today. No matter how hard—no matter how large. *Offer available through any Rockwood distributor.* All the distributor has to do is to send drive data and installation sheets to Rockwood Mfg. Co. at Indianapolis and secure written recommendation of our engineering department. We will arrange free trial drive, and guarantee the belt as well, *providing customer agrees to accept drive if satisfactory at end of free trial period.*

**Rockwood Manufacturing Company—*Indianapolis, Indiana***

## ON THE COVER

OUR cover picture illustrates one phase of the operations described in the article, *Tunnel-Lining Surgery*, which starts on page 5561. It shows a Jackhamer drilling a hole in the concrete lining through which to inject a patented compound to bind together and strengthen that lining.

●

## IN THIS ISSUE

THE title of our leading article might well be, *Making a River Run Through a Mountain*, for that is actually what engineers propose to do with the headwaters of the Colorado River. Because of a technical flaw in the act authorizing construction to proceed, the U. S. Bureau of Reclamation has announced that work on the Colorado-Big Thompson Project will have to await the passage of additional legislation by the Congress. This is in the nature of a formality, and the expectations are that it will not be long delayed.

●

"CONCRETE for Permanence" is the slogan of the Portland Cement Association, and concrete as it is now made is, indeed, a long-lasting material. When the Franklin Tunnel on the Santa Fe Railroad in California was lined, concrete technology was not so well understood, hence the current need for the operations which Lawrence A. Luther writes about.

●

A DETACHABLE bit for drilling rock is a small and apparently simple object, yet its manufacture entails a multiplicity of operations and careful attention to countless details. *How Jackbits Are Made* is designed to inform users of this popular type of bit why it is truly effective.

●

## AN EXPLANATION

IN THE article, *From Cane to Table*, in the October, 1937, issue, it was stated at the bottom of the first column, page 5434, that raw sugar comes into the United States duty free from the Philippines, Hawaiian Islands, and Puerto Rico. The word "countries" was unfortunately used in designating these islands. All are, of course, parts of the United States, although the Philippines are in transition towards independence. We regret that the wording used caused some Hawaiian readers to feel that we had classed their territory as foreign.

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## CREDIT FOR PHOTOGRAPH

THE picture reproduced on our February front cover should have been credited to the Newport News Shipbuilding & Dry Dock Company instead of to the United States Lines.

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## 1937 INDEX

THE index to Volume 42 will be mailed to any reader upon request.


# Compressed Air Magazine





Volume 43 **MARCH, 1938** Number 3

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## GRAND LAKE

**This 507-acre body of water, at an altitude of 8,400 feet, is the highest yacht anchorage in the world, and a regatta for sailing craft is held there each year. The lake is 85 miles west of Denver by road. It can be reached by either of two highways which cross the Divide at a height of more than 11,000 feet. The Colorado-Big Thompson Project will not alter Grand Lake but, by creating adjoining and even larger Shadow Mountain Lake, will probably add to the appeal this area already has for tourists and vacationists.**

**Photos from Denver Convention & Tourist Bureau**

IT IS expected that work will be started during 1938 on a 13.1-mile tunnel through the Continental Divide in Colorado to divert water from the western slope to the eastern slope. The water will provide additional irrigation for 615,000 acres of land now under cultivation in northeastern Colorado, and, incidentally, will be used for the generation of hydroelectric power. Some of this power will serve to operate pumps to lift part of the water to the level of the tunnel intake: the remainder will be available for sale. The power-generation phase of the project is to be developed gradually, only one generating station being planned for immediate construction.

The scheme involves the building of a number of dams on both sides of the divide for the storage of water. The undertaking will be carried out by the U. S. Bureau of Reclamation, and is officially known as the Colorado-Big Thompson Project. The estimated cost of the initial construction program is approximately $31,836,000, of which $24,800,000 is classified under the heading of irrigation features and $7,036,693 under power generation. The cost of providing for full power development is estimated at $19,083,243. Thus the ultimate project contemplates the expenditure of about $44,000,000.

Investigations conducted by the Bureau of Reclamation indicate that in an average year there is available on the upper drainage area of the Colorado River from 310,000 to 320,000 acre-feet of surplus water, and it is proposed to divert this through the Divide, to store it in reservoirs, and to distribute it to farmlands through existing systems of irrigation canals. The plan includes provisions that will insure the western slope against a water shortage, and has been approved by the Western Slope Protective Association.

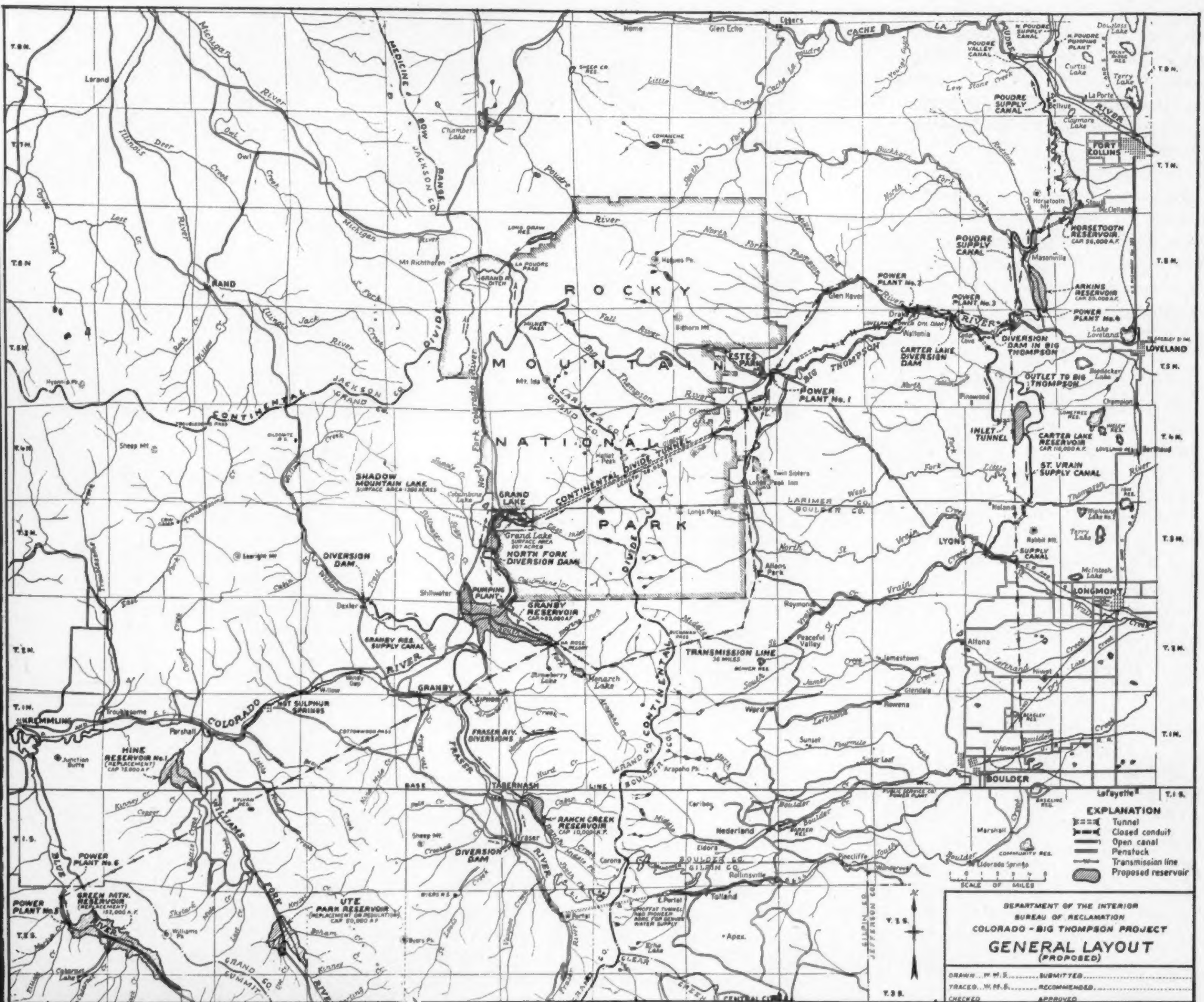
The mountain area under which the tunnel will pass lies entirely within Rocky

## BIG THOMPSON CANYON

**Most of the water from the eastern drainage area within Rocky Mountain National Park flows to the plains through this narrow gorge. The road along the Big-Thompson River, because of its scenic nature and even grade, is the principally traveled thoroughfare leading into the park from the east. Water diverted from the western slope will enter this stream after passing through Power Plant No. 1, which is to be located just below Estes Park Village, and will flow down to within a few miles of the plains. Later, when other power plants have been built, the water will be carried in conduits and dropped to the river level at four points to convert its force into usable energy.**

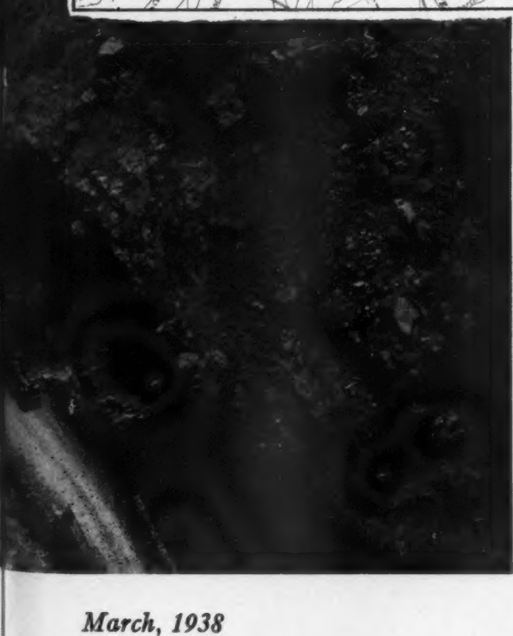
# The Colorado-Big Thompson Project

Engineers Will Reverse the Flow of the Upper Colorado River and Divert It Through the Continental Divide to Irrigate 615,000 Acres of Land.




**GENERAL MAP**

**Features of the Colorado-Big Thompson Project which is designed to increase the productivity of 615,000 acres of farmland in eastern Colorado by diverting to it surplus waters from the western slope of the Continental Divide. Ultimately, there will also be developed 135,000 hp. of hydro-electric energy. The land that is to be irrigated lies to the right of the area mapped.**



Mountain National Park, although the two tunnel portals will be just outside its boundaries. The project has been opposed by persons who are concerned with the possible despoliation of the park. These conservationists have taken the stand that the undertaking, if carried out, will set a precedent that will open the way for the construction of similar works in or near other national parks. Proponents of the scheme disclaim this, however, and point out that the bill which authorized the creation of Rocky Mountain National Park in 1915 reserved the Bureau of Reclamation the right to survey and to build an irrigation project within its boundaries. No such reservation was made in the case of any of the other parks.

The Bureau has taken cognizance of the various protests and has planned the construction features so that they will disturb the natural scenic features of the park as little as possible. In fact, a tunnel 1.6 miles shorter than the one proposed could be driven; but the longer route has purposely been chosen so that the extremities of the

tunnel will fall outside the park area. Provisions have been made for disposing of the excavated material so that few scars will remain, and for burying, on the eastern slope, a conduit that will traverse a section that may later be taken into the park. All grounds around surface structures are to be landscaped. After hearing the protests, the last session of Congress approved the project and appropriated $900,000 with which to start the work. It was approved on December 27, 1937, by President Roosevelt and Harold L. Ickes, Secretary of the Interior.

That there is need for more water in the area that will receive it is conceded. The Bureau of Reclamation states that the present supply is inadequate for fully three-fourths of the 615,000 acres concerned, and that there is no possibility of obtaining sufficient additional water on the eastern slope.

The history of this section is of interest, as it was the first in the Rocky Mountain region to be irrigated, and to it can be traced most of the irrigation laws that have since been adopted by virtually all the semi-arid states in the West. The whole section lies in the area drained by the South Platte River and its tributaries. Irrigation was first practiced there in 1860 by settlers who plowed ditches to divert water from the streams to the lowlands on either side of them. Ten years later, irrigation was extended to the slightly higher or second-bench lands contiguous to the Cache La Poudre River by members of the Old Union Colony of Greeley. This colony was formed by Horace Greeley, then editor of the *New York Tribune* and author of the often quoted advice to young men, "Go west and grow up with the country." As its first project, the colony excavated canals that carried water to 12,000 acres. The movement was successful from the start, largely because of the fact that these people had considerable means and were able to finance themselves over the period required to bring raw prairie land into profitable production.

This initial example prompted other settlers to undertake irrigation schemes, and before long there were additional areas under cultivation along the Poudre near Fort Collins, on the Big Thompson River near Loveland, and in the valley of the St. Vrain River near Longmont. This development has continued until there are now 6,400 irrigated farms served by 124 canals and ditches and 60 storage reservoirs. These lands are very fertile and, given water, yield bountifully. In the region under discussion are grown the beets from which is extracted a large percentage of the beet sugar produced in the United States. Alfalfa, small grains, beans, corn, and potatoes are the other principal crops. Much of the hay and grain, as well as pulp from the sugar factories, is fed to livestock, and the section around Fort Collins is noted for its first-quality sheep.

For many years after this area was placed under cultivation, the crops were principally grains, hay, and vegetables, and were consumed locally. They were mostly summer crops, and as the flow of the streams is greatest during late spring and early summer, when the winter's accumulation of high-altitude snow is melting, the need of irrigating water corresponded closely with the run-off. As Denver and other cities grew, and as transportation facilities were established, produce was shipped farther and farther away. Crops became more diversified, and there was a growing demand for late-season water that the streams could not supply.

To make this water available for later use, numerous reservoirs were built during the years 1890 to 1910 in which to store spring flood waters. Much of this development took place during a period of abnormal stream run-off. In the past ten years this run-off has fallen off perceptibly, with the result that insufficient water has been available and the full needs of the district could not be supplied. To make up the shortage, numerous wells have been driven and supplemental water pumped from them. This has been of some help in the areas directly concerned; but it is having the effect of lowering the water table and, consequently, of reducing the return flow of irrigating water into the streams. As the farms in the lower South Platte River Valley have relied chiefly on this return flow for their irrigating water, they are being adversely affected.


Bureau of Reclamation Photo

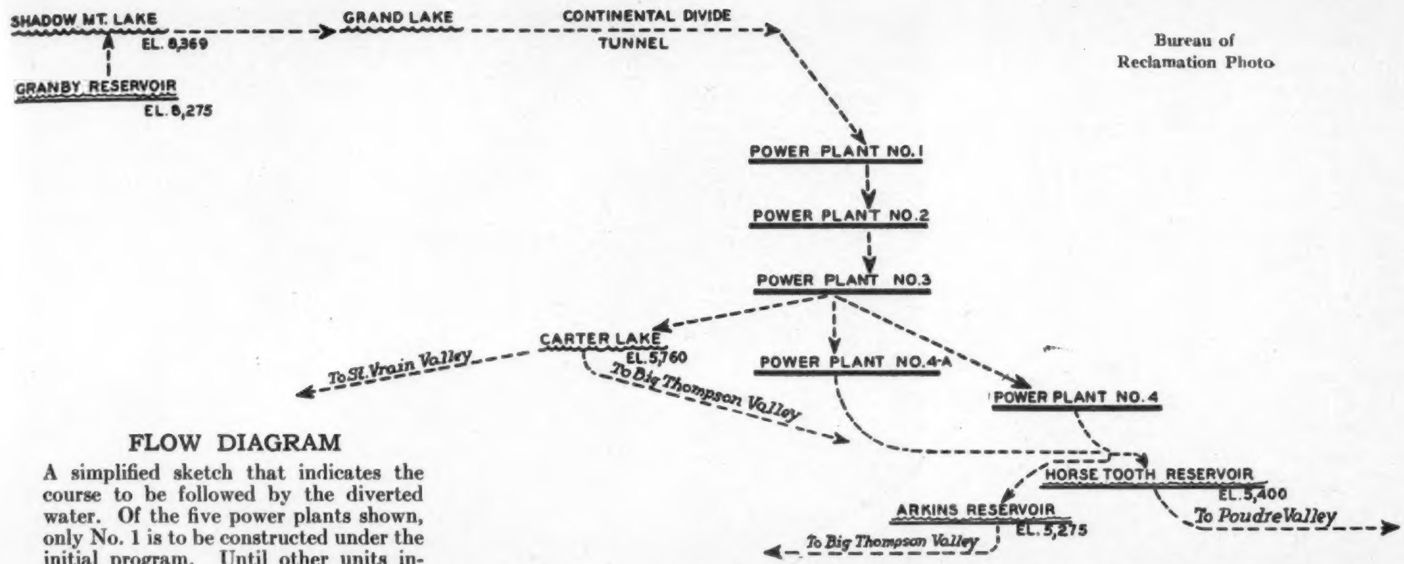
**GRAND LAKE AREA**

**An aerial photograph that shows where water will be collected on the western slope for diversion through the Continental Divide. The Granby Pump Canal, at the extreme upper left, will bring water from Granby Reservoir to Shadow Mountain Lake, which is to be created by damming the North Fork of the Colorado River. This lake will feed Grand Lake through the latter's present outlet, and both bodies of water will have the same surface elevation. Water will flow from Grand Lake to the west portal of the 13-mile tunnel through a channel, indicated at the left edge of the picture. Grand Lake occupies a basin formed by glacial action, is the largest natural body of water in Colorado, and is one of the scenic features of the state.**

On account of these conditions, only the holders of the older water rights are assured an adequate supply. In drier years, the owners of junior rights have to limit their crops to those that require little water or that will mature during the early-season flood flow. If the water supply in any year is not accurately determined beforehand, a considerable loss results.

Including some $750,000 spent on pumping plants, total expenditures on irrigation works in this district have amounted to about $35,000,000, against which there is outstanding an indebtedness of not more than $1,510,650. However, it is not possible to obtain much additional water from eastern slope sources, and it is beyond the resources of the local farmers, either individually or collectively, to carry out a project of the size required to divert an adequate supplemental supply from the western slope. It is for these reasons that the Government proposes to come to their aid.

It is admitted that the water supply in 1926 was sufficient to irrigate adequately all the acreage now under cultivation. In that year, 2,224,000 acre-feet was diverted from streams. During the 11-year period of 1925-1935, the average diversion was 1,649,000 acre-feet. The indicated annual shortage—represented by the difference between these two amounts—is 575,000 acre-feet. The average annual loss in the value of crops resulting from this deficiency has been calculated to be approximately




Bureau of Reclamation Photo

## FLOW DIAGRAM

**A simplified sketch that indicates the course to be followed by the diverted water. Of the five power plants shown, only No. 1 is to be constructed under the initial program. Until other units included in the power scheme are built, the water will flow from Power Plant No. 1 down the Big Thompson River to a diversion dam, and thence into storage reservoirs from which it will be drawn as required to feed the existing irrigation canals supplying water to farmlands. The tunnel will be operated during the autumn, winter, and spring months, thereby insuring full storage reservoirs by July 1, when the demand for supplemental irrigating water normally starts.**


## CONTINENTAL DIVIDE—ESTES PARK AREA

**An aerial view of the eastern slope of the main range, showing the route of the tunnel and of the connecting conduit through which the water will flow to Power Plant No. 1. All the area in the foreground lies within Rocky Mountain National Park, of which Estes Park Village is the largest settlement. The region is dotted with hotels, and is a popular tourist center during the summer months. The structures required for the Colorado-Big Thompson Project have been planned so as to safeguard the scenic features of the park.**

$4,700,000, and for the period 1925 to 1934, inclusive, it has been set at $42,355,000. It will be noted that the average annual loss is about 19 per cent of the estimated cost of the irrigation features of the Colorado-Big Thompson Project. These figures represent only the loss in income sustained by the farmers. Total losses to the community include the sums that would have been paid for transporting, processing, and handling the additional crops that would have been raised if sufficient water had been available—sums that would increase the figures given by several million dollars. As an indication of the value placed on water, it may be cited that the sale or rental of supplemental water, when it has been available, has averaged $4.50 an acre-foot for years and has at times reached $9 an acre-foot.

It is calculated that if 310,000 acre-feet of additional water is diverted to these lands, there will result from such diversion a usable return flow to the streams of 214,500 acre-feet. It is also expected that 30,000 additional acre-feet will be returned to streams following the diversion of water from the western slope by the City of Denver through the Moffat Tunnel. The total supplemental supply will, accordingly, be 554,500 acre-feet a year, or 20,500 acre-feet less than the computed average deficiency.

Looking towards the possible provision for this district of supplemental water from eastern-slope sources, a study was made in 1929 by local consumers, the State of Colorado, and the U. S. Army Engineers. Using the data gathered at that time and bringing the figures up to date, the Bureau of Reclamation has computed that during the period 1918–1935 there was an average annual excess supply of 62,000 acre-feet on the watersheds of the Cache La Poudre, Big Thompson, and St. Vrain rivers. The cost of constructing reservoirs in which to impound it would, however, amount to $160 per acre-foot. In contrast with this, the cost per acre-foot under the Colorado-Big Thompson Project will be only $80. Besides, it will be possible to store 16,000 acre-feet of surplus waters from the Big Thompson River at no additional cost in new reservoirs that are to be built.

The mountainous barrier that is to be pierced by the tunnel is responsible for the plentiful supply of water on the western slope and the comparative scarcity of it on the eastern slope. This great uplift has an average altitude of more than 11,000 feet, and rises in numerous places to a height of more than 14,000 feet. The prevailing winds are from the west, and as the clouds borne by them move up the slope they encounter high-altitude cold that causes them to precipitate most of their moisture. The accumulation of snow is very heavy in the winter and has a tendency to remain longer on the western than on the eastern slope because it is protected from the sun's rays during the greater part of each day.

Topographically, there is a marked contrast between the eastern and the western sides of the Divide in Colorado. From the eastern base, the plains stretch out in a

gentle downward slope that is broken very little by elevations of any consequence. Accordingly, this great expanse, comprising roughly the eastern half of the state, is potential agricultural land that requires only water to make it highly productive. West of the main divide, in contrast, the surface is highly irregular, consisting of a succession of mountain ranges. Here and there are broad valleys that can be farmed, but their combined area is only a fraction of the arable land on the eastern slope.

The physical nature of the western half of the state is therefore such, fortunately for the eastern half, that some of its ample supply of water can be spared. After allowing for the needs of all arable land now under irrigation and capable of being placed under irrigation, the Bureau of Reclamation has determined that even in a year such as 1931, when the run-off of the streams that are to be tapped was only 40 per cent of the 31-year average, the diversion of the amount of water that it is proposed to divert would leave the Colorado River drainage basin only 53,000 acre-feet short of all requirements for irrigation and power generation. However, to make certain that the western slope shall be adequately cared for, the plan includes provisions for impounding water that can be released to make up any deficiency that may develop.

With these general considerations set forth, we may now look at the Colorado-Big Thompson Project in more detail. The scheme calls for three reservoirs on the western slope. Of these, the Green Mountain Reservoir will store no water for diversion, its sole purpose being to provide replacement water to protect the users in the Colorado River Basin against any depletion of their supply by its diversion to the eastern slope. In addition to the irrigation requirements, the Shoshone hydroelectric generating plant of the Public Service Company of Colorado, located on the Colorado River near Glenwood Springs, uses up to 1,250 second-feet of water.

Green Mountain Reservoir will be built on the Blue River at a point about 16 miles from Kremmling. It will flood 2,100 acres of land and will have a capacity of 152,000 acre-feet. Because there would have been a water shortage of 53,000 acre-feet on the western slope in 1931 if the Colorado-Big Thompson Project had been in operation, 50,000 acre-feet of water will annually be allocated from Green Mountain Reservoir for replacement purposes. For this, the water users on the eastern slope will pay $1,500,000 towards the cost of the reservoir. The remaining 100,000 acre-feet will be allocated to power generation. The total

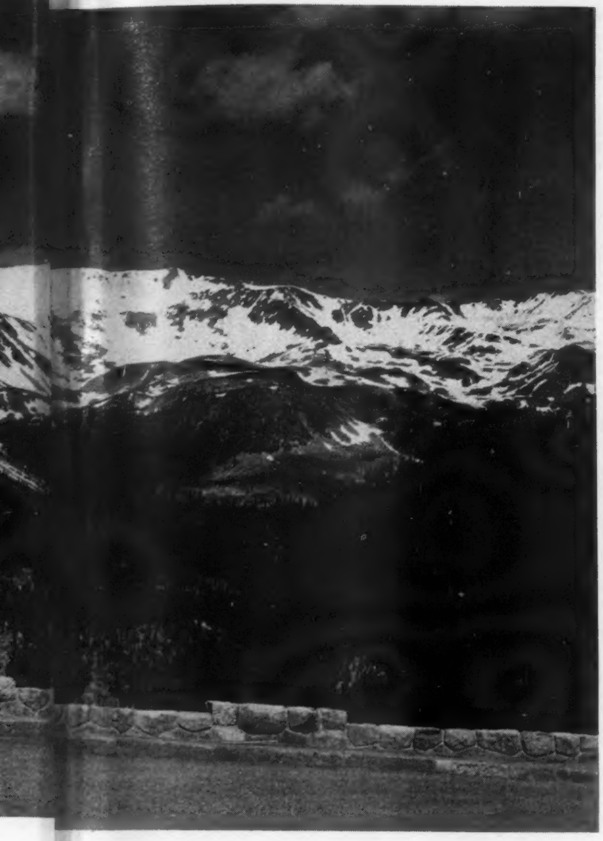
Photo from Denver Convention & Tourist Bureau

estimated cost of the dam and reservoir is $3,776,032, of which $2,276,032 will be derived from power revenues. The power plant, designated in the scheme as No. 5, will not be constructed at present. It will develop 26,000 kw. and will cost, complete with substation and transmission line tying it with the rest of the system, $1,627,400.

The water that is to be diverted through the mountains will be stored in a reservoir to be located about 4 miles from the Town of Granby. It will occupy parts of the valleys of the main Colorado River, of its south fork or Arapaho Creek, and of Stillwater Creek. In addition to the water from these sources, it will receive the flow of Willow Creek through a diversion canal having a carrying capacity of 1,000 second-feet. This stream now enters the Colorado River about 2 miles downstream from the dam site. In a similar manner, the waters of Meadow and Strawberry creeks, tributaries of the Frazer River that flows into the Colorado about 5 miles downstream from the dam site, will be diverted to the reservoir by a canal having a capacity of 500 second-feet. Granby Dam will be situated at the head of a short canyon that cuts through pre-Cambrian rocks. It will be a combination earth-fill and rock structure of 223 feet maximum height. At high water line the reservoir will flood 6,943 acres and will have a capacity of 482,860 acre-feet. Its estimated cost is $2,813,703, and the two diversion canals are estimated to cost $866,863.

The water stored in Granby Reservoir will be run through a 4½-mile gravity-flow canal into Shadow Mountain Lake, thence it will flow into Grand Lake, and from there it will be diverted through the Divide. As the high water level of Granby Reservoir will be at elevation 8,275 and that of Shadow Mountain Lake will be at elevation 8,369 it will be necessary to lift the water by pumping to get it into the feeder canal. To accomplish this, a pumping plant will be constructed on the north shore of Granby Reservoir. It will house three vertical-shaft pumps each to be driven by a 6,500-hp. synchronous motor. Their combined capacity will be 550 second-feet at low water level, 870 second-feet at normal water level, and 900 second-feet at high water level. The canal will be designed to carry the maximum pumping capacity of 900 second-feet. The plan is to operate this canal throughout the winter when temperatures get as low as 40° below zero Fahrenheit. The latent heat in the water and the friction heat absorbed from the pumps will prevent the water from freezing and will maintain a considerable open area at the entrance to Shadow Mountain Lake. The respective estimated costs of the pumping plant and of the canal are $1,250,000 and $417,553.

Shadow Mountain Lake will be formed by building a 35-foot concrete overflow dam across the North Fork of the Colorado River. The dam site is about ½ mile downstream from the junction of the North Fork and the outlet of Grand Lake. The latter body of water is the largest natural lake in Colorado, is situated within Rocky Mountain National Park, and has long been considered one of the foremost scenic attractions in the state. Its shores and neighbor-



THE NEVER-SUMMER MOUNTAINS

This attractive vista greets the traveler in Rocky Mountain National Park from Far View Curve on Trail Ridge Road. The lofty peaks are largely covered with snow until late summer, patches remaining on them throughout that season save in years of exceptionally light precipitation or uncommonly warm summers. This picture was taken in June, 1937.

ing areas are built up with cottages and hotels which are occupied by summer residents and tourists. Accordingly, special care has been taken to plan the structures in that area so that they will not detract from the natural beauty.

Shadow Lake will have a surface area of 1,356 acres and will cover a section that is now an unattractive swamp and a breeding place for mosquitoes. The approach road to the western entrance of Rocky Mountain National Park will run along its shore. Shadow Lake will be connected with Grand Lake by the latter's existing outlet, and both will have the same elevation.

Water will flow from Grand Lake to the west portal of the Continental Divide Tunnel through a channel 67½ feet wide, 15 feet deep, and approximately 740 feet long. A concrete barrier or weir, having a crest elevation of 8,368 feet, will be constructed at the lake end of the channel. To supply the normal capacity of the tunnel the water will be 1 foot deep over this weir, and the normal level of the lake will accordingly be at elevation 8,369. As the maximum drawdown will be 1 foot, the level of the lake cannot go below elevation 8,368. This fluctuation of 1 foot compares with a present fluctuation of 4 feet.

The Continental Divide Tunnel will be 69,023 feet long. It will be of horseshoe-shaped section, 9½ feet in diameter, and will be lined with 9 inches of concrete. It will penetrate igneous rocks of which approximately three-fourths are granites and the remainder are gneisses and schists. From geological investigations that have been made, and from a study of conditions that were encountered in driving the Moffat Tunnel about 25 miles to the south, it has been estimated that only 5,200 feet of the bore will have to be supported and that only 400 feet will be in really bad ground. To be conservative, however, it was assumed, in preparing estimates of cost, that 17,500 feet would require support and that 6,900 feet could be classed as bad ground. On this basis, the estimated cost of the tunnel is $7,271,371. It is expected that it will be driven from the two ends simultaneously, with no intermediate shafts. The spoil from the western end will be used to fill in low areas to make them more suitable for the building of summer homes. The waste from the eastern portal will be terraced and planted with evergreen trees.

The structures on the eastern slope will consist of three reservoirs for storage and control of the water supply, interconnecting conduits and canals, five power plants, transmission lines, and appurtenant works. The water will flow through the Continental Divide Tunnel by gravity and will reach the eastern slope at a point in Wind River Canyon about 5 miles southwest of Estes Park Village. From there it will flow by gravity a distance of 5.36 miles to Power Plant No. 1 to be located on the Big Thompson River a short distance downstream from Estes Park. It will traverse this stretch by way of 1.33 miles of open canal; 1.86 miles of buried, 10-foot, reinforced-concrete pipe; 1.19 miles of concrete-lined tunnel; and 0.98 mile of siphon. The estimated cost of this conduit is $1,101,000.

Power Plant No. 1, which is the only one that is to be built under the current program, will contain two 15,000-kw. generators driven by vertical hydraulic turbines operating under a head of 705 feet. From Estes Park, the Big Thompson River flows through a canyon for a distance of some 20 miles before it emerges upon the plains. It has a considerable fall. Ultimately, it is proposed to direct the water that is discharged from Power Plant No. 1 through a system of conduits to Power Plant No. 2 and thence to Power Plant No. 3, both of which are to be located in the canyon. The first of these is to have a capacity of 50,000 kw. and the second a capacity of 13,000 kw.

Until a market for this power develops, the water from Power Plant No. 1 will be discharged into and flow down the Big Thompson River to Carter Lake Diversion Dam to be situated about 12 miles west of the City of Loveland. This dam will divert the flow into a canal with a capacity of 750 second-feet that will traverse the south side of the canyon wall for a distance of 4.93 miles. At this point, which is just above the termination of the canyon section of the Big Thompson River, some of the water will be allowed to drop directly into the river to supply the supplemental needs of that stream and some will be siphoned across the river to the north side to supply a canal that will run to the Poudre River to the north. Advantage will be taken of the fall of 550 feet to the Big Thompson River and of that of 358 feet to the Poudre Canal for the generation of power in power plants Nos. 4 and 4-A when the market demand justifies their construction. The former will develop 16,000 kw. and the latter 7,000 kw. The estimated cost of the power canals is $1,194,000.

The water remaining in the canal leading from the Carter Lake Diversion Dam will be directed southward through still another canal section 8.78 miles long of which 7,040 feet will be in tunnel, 1,878 feet will be siphon, and the remainder will be open ditch. This canal will have a carrying capacity of 300 second-feet, and it is estimated that it will cost $710,629. It will lead to Carter Lake Reservoir, which will be formed by constructing three earth-and-rock-fill dams having respective heights of 243, 48, and 43 feet. This reservoir, at high water level, will flood 1,150 acres and will contain 111,963 acre-feet of water. From it a 5.37-mile canal with a capacity of 1,000 second-feet will run to Cottonwood Creek, a tributary of the Big Thompson River, and a 9.76-mile canal with a capacity of 300 second-feet will extend southward to the St. Vrain River. These canals, whose estimated costs are $368,951 and $155,246, respectively, will furnish water for irrigation to existing canal systems as it is needed.

From the outlet of the siphon that will supply Power Plant No. 4 when it is constructed, a canal will run northward to Horsetooth Reservoir. This canal will be 9.88 miles long, and 12,863 feet of it will be in tunnels, 3,296 feet in siphons, and the remainder will be open. Its estimated cost is $1,208,391. Horsetooth Reservoir will be formed by constructing four dams at an estimated total cost of $3,625,021. It will flood an area of 1,513 acres and will have a capacity of 96,756 acre-feet. From its outlet a canal with a capacity of 1,000 second-feet will reach northward to Lewstone Creek, down which the water will flow to the Poudre River. A supplemental canal with a capacity of 400 second-feet will extend from Lewstone Creek to the existing Poudre Valley Canal, crossing the river in a siphon. Water diverted in this manner will flow down the canal a distance of 3.58 miles to the North Poudre pumping plant. There two motor-driven pumps, each having a capacity of 75 second-feet, will raise it 187 feet to a canal 9.98 miles long that will carry it to the North Poudre Canal. The estimated cost of the pumping plant

is $200,000: that of the canal is $128,889.

Just north of the Big Thompson River, near the point where it emerges from the mountains, Arkins Reservoir will be constructed. Its purpose will be to impound western-slope water and also 16,000 acre-feet of Big Thompson flood water that is not now stored. It will have a capacity of 50,000 acre-feet and will flood 929 acres of land. It will be formed by building an earth-and-rock-fill dam 155 feet high and a smaller dam of the same type 50 feet high. An inlet canal 2.33 miles long will be constructed to connect it with the river. Impounded water will be released and turned back to the Big Thompson River through a tributary as it is required for irrigation. The estimated cost of this reservoir is $1,740,737 and of the inlet canal $351,488.

It is planned to operate the system so that Carter Lake, Horsetooth Reservoir, and Arkins Reservoir will be filled to their combined capacity of 256,000 acre-feet by July 1. The demand for supplemental irrigating water ordinarily begins near that date and continues until September 15 or 30. The outlets of the reservoirs will be of such capacities that they will be able to deliver all the stored water during this 60- to 75-day period, as well as the additional 54,000 acre-feet that will reach them from the western slope during that time.

Most of the water to be diverted will flow into Granby Reservoir during May, June, and early July, when the snow is melting. It will be transferred to the east slope through the Divide at a uniform rate during the following autumn, winter, and spring, thus aiding in the development of firm power in the five hydro-electric plants that will eventually be built along the Big Thompson River. During the summer, less water will be diverted, for then a considerable volume will be available in the Big Thompson River for the generation of power. As there will be little demand for power for pumping at the Granby Reservoir pumping plant during that period, the generation of power can be regulated in accordance with the commercial load.

The Granby pumping plant and the canal that will supply water to Shadow Mountain Lake for diversion have both been planned to deliver 150 per cent of the capacity of the Continental Divide Tunnel. It will therefore be necessary to run the pumping plant only sixteen hours a day to operate the tunnel the full 24 hours. This will make it possible to use off-peak power for pumping, with a consequent reduction in the use of firm power. The sixteen hours of pumping will be timed so that a large block of the power generated will be available when it is needed to meet peak commercial loads.

Full development of the power system contemplates the erection of 146 miles of 34,500-, 69,000-, and 115,000-volt transmission lines at a cost of $942,000. Their routes are shown on an accompanying map. To provide power for construction purposes, one of the first operations will be the building of a 46-mile line from the Valmont generating station of the Public Service Company of Colorado to the site of Power Plant No. 1, of a 36-mile line from Power Plant No. 1 to the site of Granby Reservoir, of a 36-mile extension from that line to the Green Mountain Reservoir site, and of another extension to the site of the west portal of the Continental Divide Tunnel. All but the last of these will become parts of the permanent transmission system.

As previously stated, the estimated cost of the features of the plan chargeable to irrigation will amount to $80 for each acre-foot of water that will be made available. To insure repayment of the expenditures to the Government, it is expected that contracts will be made with the water users on the basis of $2 an acre-foot for 40 years. This financing plan has been worked out on the supposition that 310,000 acre-feet of additional water will be provided. However, it is estimated that the diversion from the western slope will average 320,000 acre-feet annually, and that in normal years 16,000 acre-feet of the run-off of the Big Thompson River that is not now being stored will be impounded. Accordingly, it is expected that 26,000 acre-feet over and above the quantity on which the financial set-up is founded will be normally available to make up losses on the eastern slope and to meet the demands of western-slope water consumers in years in which the supply is less than the average used as the basis for the scheme.

Based on water-supply studies, and with only Power Plant No. 1 in operation, it is figured that there will be available, above all requirements for pumping services, a constant power output at 100 per cent load factor of 120,000,000 kw-hrs. a year. It has been assumed that a market can be found which has a load factor that will permit 60 per cent of this power, or 72,000,000 kw-hrs. a year, to be absorbed as firm energy. The remainder, or 48,000,000 kw-hrs., plus about 40,000,000 kw-hrs. which will be available during various parts of the year, has been classed as secondary energy. No arrangements have been made for utilizing this power, but it is considered likely that the 75,000-kw. Valmont steam plant of the Public Service Company of Colorado will absorb this 88,000,000 kw-hrs. of secondary energy as a fuel-saving measure if the price does not exceed the company's present cost of generation.

It has been computed that 5 mills a kilowatt-hour can be secured for firm energy and 1.8 mills for secondary energy. Allowing for a 10 per cent loss in transmission, the sale of all available power at these figures would yield a revenue of $467,000 a year. It is believed that $20,000 a year additional can be obtained from rental of water to privately owned power plants. The estimated investment in power features of the first stage of the program is $7,036,693. It is proposed to repay $3,831,000 of this, together with 3 per cent interest, in 50 years, and the remaining $3,205,693 without interest in 40 years. The total annual power revenue of $487,000 just enumerated would not only permit this but would also meet all operating charges and provide a surplus of $92,000 a year.

Full development of the power features would make available annually 360,000,000 kw-hrs. of firm power and 200,000,000 kw-hrs. of secondary power.

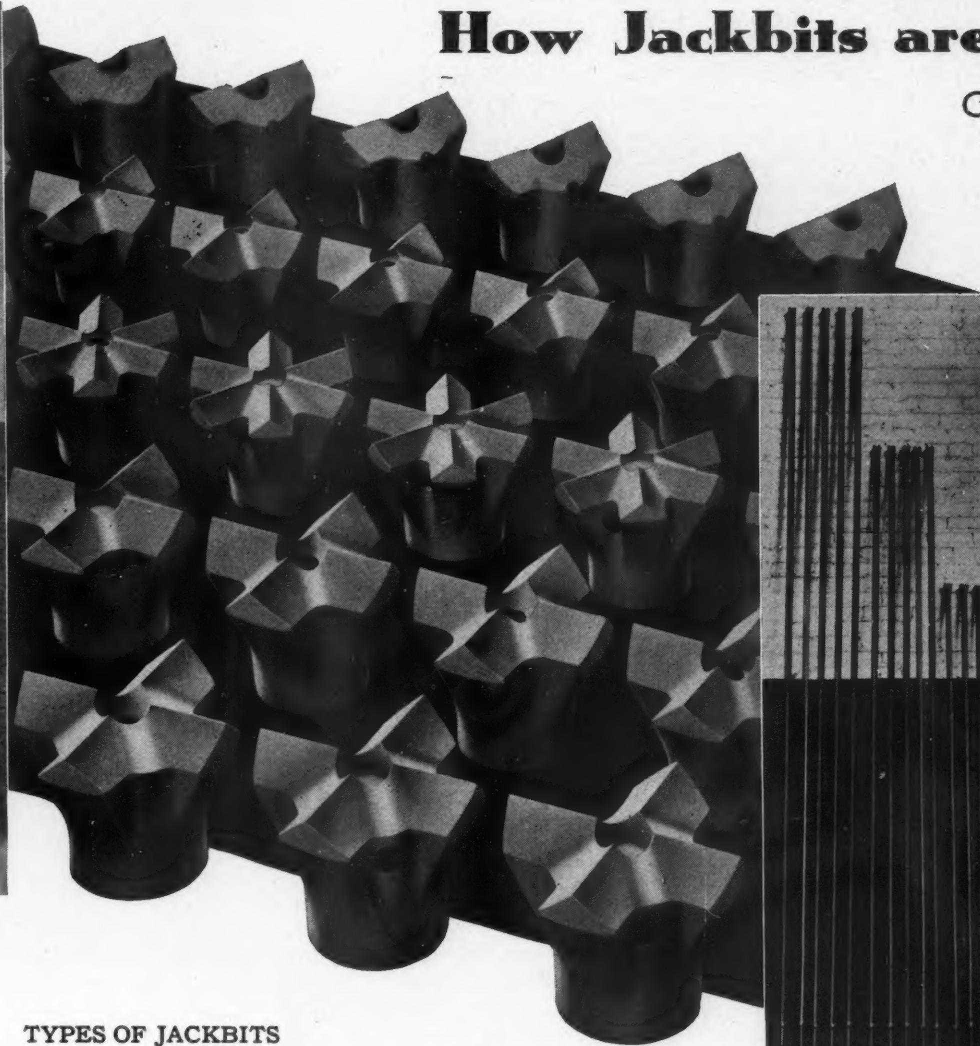
Bureau of Reclamation Photo

**SITE OF EAST PORTAL OF TUNNEL**

**The eastern extremity of the 13-mile long, 9½-foot diameter, concrete-lined bore will be in Wind River Valley, about 5 miles southwest of Estes Park Village, and outside the boundary of Rocky Mountain National Park. It will be driven from both ends at an estimated cost of $7,271,371. Its location is about 25 miles north of the Moffat Tunnel, a railroad bore that was excavated about fifteen years ago.**

# How Jackbits are Made

C. H. Vivian



**TYPES OF JACKBITS**

**There are three standard types of Jackbits: 4-point, 6-point, and Carr (chisel). The 4-point is most used, and comes in a complete range of sizes from $1\frac{3}{8}$ to $3\frac{1}{2}$ inches in diameter. The others are made in the most popular sizes. All bits may be had with the air or water hole through either the center or the side.**

**ECONOMY IN JACKBITS**

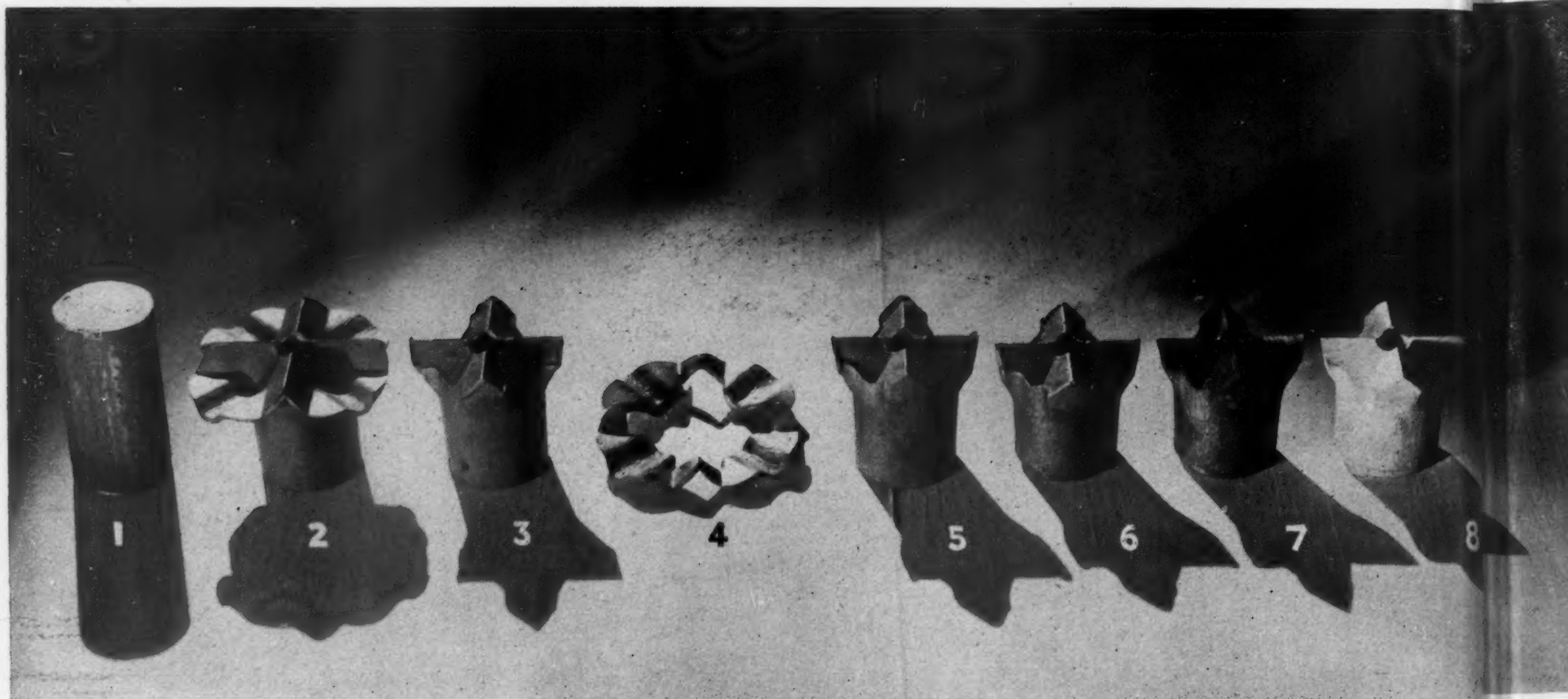
**The picture just above and the one at the extreme left graphically illustrate the reduction in drill steel that is made possible by the use of Jackbits. Above is a 1-shift supply of conventional drill steel for one Jackhamer working on 10-foot holes. At the left is the supply of drill rods and Jackbits—24 in number—that will do the same work. As the rods remain at the drilling location, the transportation of long steels to the shop for reconditioning is eliminated.**

ONE of the outstanding advances in rock-drilling technique in recent years is the introduction of the detachable bit. Carefully conducted tests in connection with drilling operations of various kinds have shown conclusively that this new development materially reduces the cost of putting in blasting holes. As a consequence, the use of detachable bits is increasing rapidly.

The separation of the drill steel into two parts is the natural result of the continued increase in power of rock-drilling machines. By employing alloy steels and other special materials for drill parts, designers have been able to build machines that will not only deliver harder blows but also stand up under that pounding. At the same time, they have been somewhat restricted by the physical limitations of the drill steel. This is true because drill steel must have resistance not just to one destructive force but to several. The cutting end, or bit, must be hard enough to penetrate rock rapidly, but not so hard that it will shatter under the sustained impact of 2,000 or more blows per minute. The opposite end, or shank, must be hard enough to resist upsetting by the piston that strikes it, and yet not so hard and brittle that it will be shattered by or, in turn, perhaps damage the piston. The remainder of the steel must be capable of absorbing tremendous vibratory stresses without failing too soon from fatigue. To meet all these requirements, and to do so with one bar, has necessarily called for a compromise, which in this case has meant sacrificing hardness in the bit for greater fatigue life in the bar.

The detachable bit has removed the need for this compromise. It is now possible to make the bit from steel having characteristics that give it maximum cutting capacity. Similarly, the rod material can be chosen because of its capacity to withstand fatigue stress, and without regard to its rock-cutting capability. When such a bit and rod are screwed together, a drilling element results that will stand up better in service than any single piece of steel that metallurgists have been able to produce. In effect, this trend towards drill steel fashioned of two individual parts each having a different composition is analagous to the long prevailing practice of making drilling machines of parts whose respective compositions fit them for their particular services.

Of importance to the drill user is the fact that detachable bits will, in most cases, save him money. This saving is the result of two principal factors: First, a detachable bit will drill faster than the average conventional bit forged on bar steel in the field. It will drill more hole before becoming dull, which means that sharp bits will be in use a greater percentage of the time. These things are true because detachable




**STEPS IN MAKING A JACKBIT**

No.1 is a slug of bar steel for making a 2-inch-gauge, 4-point, standard bit. No.2 shows it after being forged and with the flash adhering. No.3 is the trimmed forging and No.4 the removed flash. No.5 illustrates the forging after being milled to accurate gauge. No.6 shows it after reaming, tapping, and drilling of the center hole. In No.7 the cutting edges have been formed. No.8 is the finished bit, which has been heat-treated to the correct hardness and protected against corrosion by metal plating. The weight of a Jackbit varies with its size, the average being around 1 pound. The slug from which a 1-pound bit is made weighs approximately 1⅓ pounds before processing.

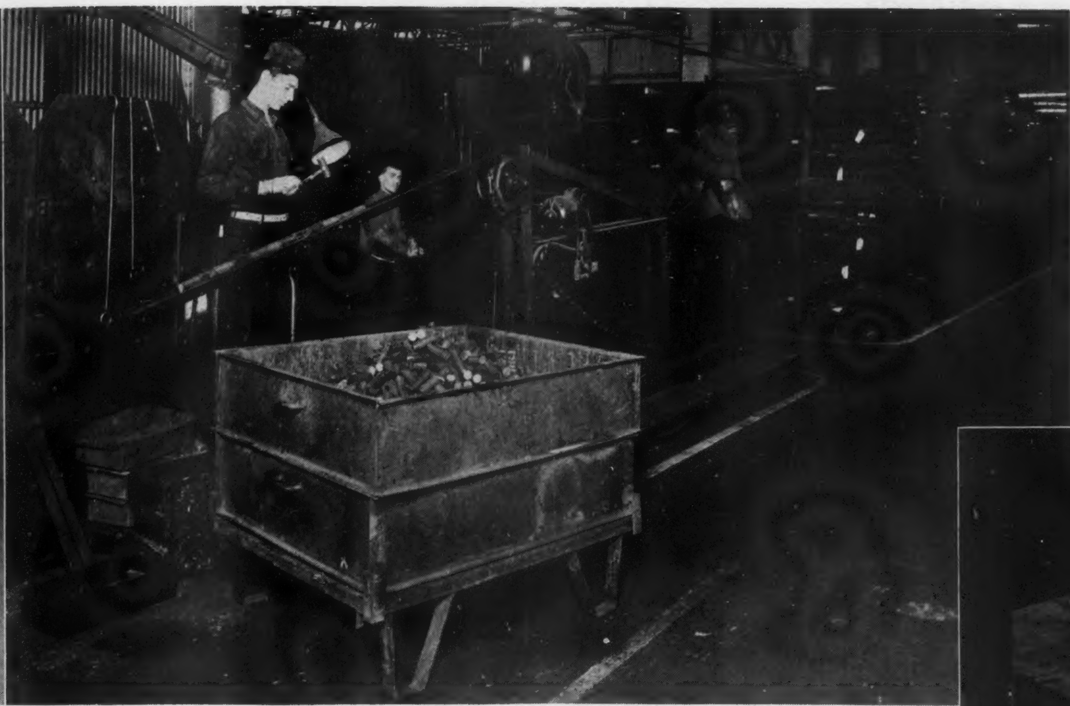
bits are made of material that is selected solely because of its powers of penetration —its capacity for keeping cutting edges and gauge. Moreover, every detachable bit is factory heat-treated and sharpened and will, accordingly, drill faster than the average bit forged in the field where few shops are equipped to perform the best possible job.

Because detachable bits drill faster and stand up longer than most fitted steel bits, fewer bit changes are required to drill a hole of given depth. As the size of bits must be progressively decreased so that each will follow the preceding one without binding, this reduction in the number of bits used makes it possible to start a hole with a smaller diameter than that required with conventional steels. In other words, the average size of the hole is smaller; the total rock displaced is less; and the drilling machine consequently performs less work. Because of this, and of the resultant faster drilling, the air consumption per foot of hole drilled is less and upkeep costs of drills are lower.

The second main consideration is that with detachable bits the cost of transporting steels to and from drilling locations for reconditioning is practically eliminated. This is so because the drill rods remain at the drilling location, save for occasional trips to the shop for rethreading or reshanking. The initial investment in steel can therefore be greatly reduced, the saving sometimes amounting to as much as 80 per cent, compared with the stock required when using solid-forged steels. The drill runner takes his supply of bits with him at the start of his shift and returns them to the shop for resharpening when his shift is completed. Nippers, steel carriers, etc., are reduced in number, and the blacksmith's costs are materially lessened. As no two drilling operations are identical, the overall savings effected by detachable bits will vary with conditions, but experience indicates that they will usually be somewhere between 10 and 40 per cent.

With regard to the smaller supply of drill rods needed when detachable bits are used, it may be pertinent to state that there are some mistaken impressions as to what constitutes an adequate stock to keep all drilling machines on a job in operation. It should be borne in mind that forged-bit steels are in actual service only a few minutes at a time and are then out of service for from several hours to several days while undergoing reconditioning. With such a routine, a given piece of steel may be utilized only once or twice a week. If it does not break for, say, three months, it would seem to have lasted a long time, although its actual service life may be only one hour. On the other hand, with detachable bits, the drill rods stay on the job, and each of the different lengths is used over and over during each shift. Thus, a rod may give as much service in one shift as conventional steel aggregates in three months. Users should bear this fact in mind and make ample allowance for the failures that are bound to occur where steel undergoes such severe punishment. Experience has proved that a safe rule to follow is to provide a stock of drill rods totaling at least one-quarter the weight of the solid-forged steel that would be required for the same operation. In other words, if 10 tons of solid-forged steel is required per month to keep a job going, drill-rod replacements should be supplied at the rate of 2½ tons per month.

However, aside from the reductions in drill-steel investment and in transportation costs, other savings in bar steel are effected when detachable bits are used. It has been found that conventional drill steel loses on an average from ¼ to ⅓ pound with each resharpening. With steel costing twelve cents a pound, the aggregate daily loss in bar steel on an operation where 1,000 pieces pass through the sharpener shop each day will consequently be around $40. This loss is attributable to several factors, chief among which are: steel worn off the bit in drilling (in the case of detachable bits this comes off the bit and not the rod); scale loss in heating bits for resharpening and rehardening; loss from breakage of wings of bits because of improper heat treatment; and loss from broken shanks, or breakage of the bar itself. Much of this breakage is traceable to small pits caused by rust or by minute surface nicks. Where detachable bits are used, drill rods undergo such intensive service that the steel is often worn



**MAKING THE FORGING**

**Each Jackbit is forged from a slug of steel. The first operation consists of shearing bar steel into sections. The slugs are elevated from the shear and conveyed back to an inspector (above), who examines each one and discards any that are faulty. Slugs are then heated and forged in dies such as the one shown at the right. Surplus metal is squeezed out over the face of the die. This flash is trimmed off in a press and the forging placed in a machine which mills it to accurate gauge, or diameter.**

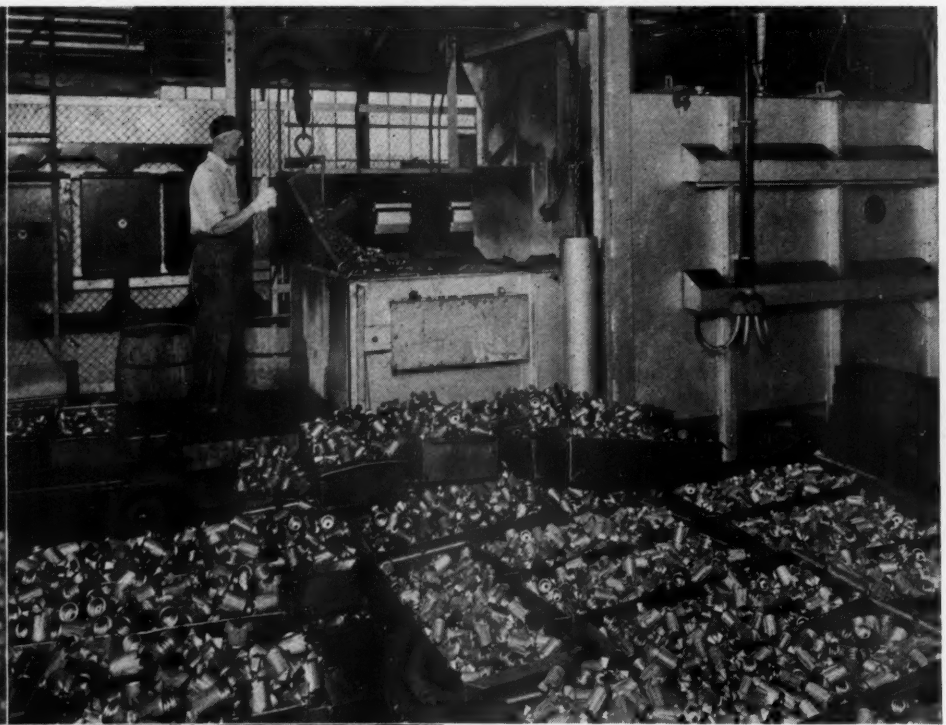
out in useful work before rust pits have time to develop and cause breakage, while the reduction in the number of trips to the blacksmith shop saves them from much of the surface damage that results from frequent handling. Another source of shrinkage that looms large in the aggregate is the inevitable direct loss—that is, steels that are misplaced, cast aside, or covered with muck and never recovered. With detachable bits, each drill operator has only a comparatively few drill rods to look after, and the chances of loss are greatly reduced.

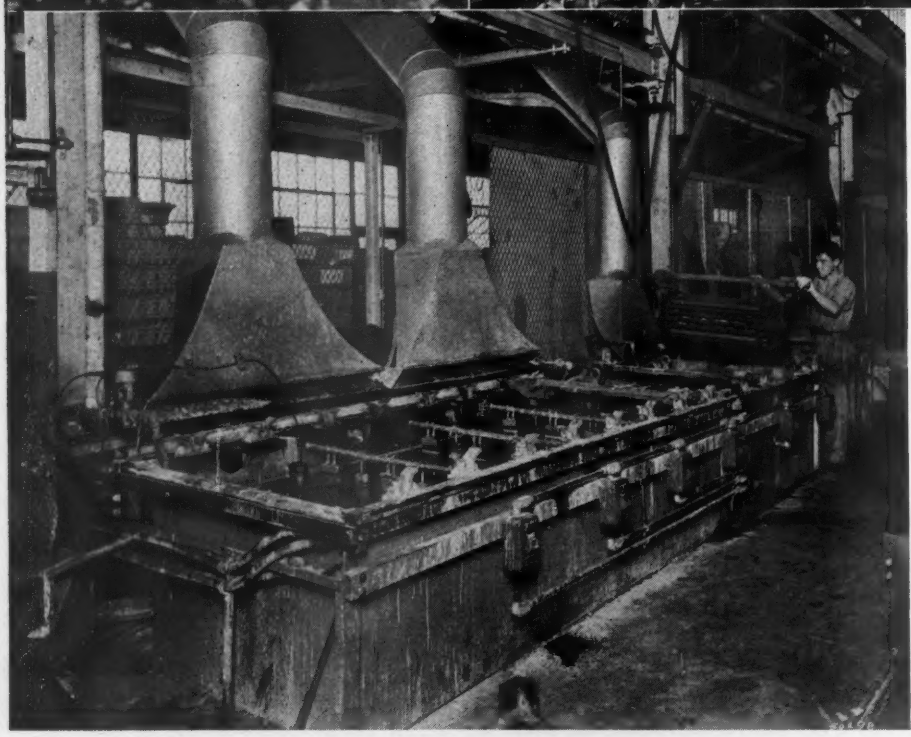
As might be expected, the rise of detachable bits to such an important place among drilling equipment has caused manufacturers to pay increasing attention to their design and to the methods by which they are produced. By way of amplifying this statement, we shall outline in some detail the procedure followed by Ingersoll-Rand Company in making the detachable bits which it markets under the name of Jackbits. This product is turned out at Phillipsburg, N. J., where the company has concentrated its domestic rock-drill manufacturing facilities. But before we do this, a tribute should be rendered to the old-time hand drillers for the thoroughness with which they tried out the various types of "X," "Z," chisel, and 6-point bits before deciding on the 4-point cross bit as the one being most generally satisfactory.

When the manufacture of Jackbits was started, it was recognized that the bit should no longer be so shaped that it could be readily formed in a conventional drill-steel sharpener. Accordingly, all the old shapes were once more tried out, in addition to many new and novel designs, and again the 4-point bit demonstrated its outstanding superiority by drilling a large majority of the different rocks in the world, thus corroborating the earlier findings. Today, certain kinds and sizes of Jackbits of the Carr and 6-point types are available, as well as standard 4-point cross bits. However, the demand for the first two is very limited, representing, combined, only a small percentage of the total sales in those sizes.

A Jackbit is a small article and, in its finished state, appears to be rather simple and easy to make. Actually, however, a surprisingly large number of individual operations enters into its manufacture and, throughout the entire process, very close control is exercised. This is necessary so that all bits will be of the same high quality and that each one will perform as it is supposed to when called upon to drill rock, whether that be on a New York subway contract, a highway-building project in Tennessee, or in a western metal mine. The same care and attention to detail are given to the manufacture of Jackbits that attend the making of a precision rock drill. Both products are designed by the same engineers, the materials that enter into them are checked in the same modern laboratories, and they are both made by highly skilled men with the aid of the best mechanical equipment obtainable. In order that Jackbits may have a full measure of close supervision and careful handling at every step of their manufacture, a separate department has been assigned to them that draws, however, upon the full technical resources of the rock-drill division.

Control starts long before Jackbits are actually in course of production. It is first exercised in the mills that furnish the steel or raw material for the bits. The specifications for this steel are written by Ingersoll-Rand metallurgists. As already set forth, it is a special steel made in the United States and selected for this particular service. In the layman's language, it is a high-carbon tool steel. It is of the same quality as that used for making high-grade files and similar tools that must retain cutting edges, as well as such articles as blanking and pressing dies which demand hardness and toughness. The metallurgist describes it as a "grain-size-controlled steel selected according to its hardenability." The principal requirements are a fine grain structure and capacity to harden to the desired degree and to the desired depth. Standard Jackbits are made in a complete range of sizes from 1⅜ inches to 3½ inches in diameter. It will be realized that what may be a suitable depth of hardening for a small bit would be entirely inadequate for a large one. For that reason the steel mill is given several specifications to guide it in pro-





**FINISHING OPERATIONS**

**Forgings of rough bits are annealed, sand-blasted to remove scale, the threads for affixing them to the rods are drilled and tapped, and the cutting edges are accurately milled. The bits are next washed free of adhering oil and hardened in a continuous-type electric furnace that is equipped with the most modern temperature-control apparatus and instruments (top right). Upon issuing from the furnace, they are immediately placed on a special fixture (top left) where the cutting edges are quenched in water for a period that varies with the size and type of the bit. Next they are tempered in precisely controlled electric furnaces. The final operation (lower view) consists of giving them a silvery metal finish to prevent their rusting and to make them readily visible in mines and other drilling locations where lighting is poor.**

ducing the distinct products from which the factory makes its selection, based on the hardness-penetration characteristics of the stock, for the various-sized bits.

The steel is rolled into round bars of eight sizes ranging from 1 inch to 2¼ inches in diameter. After it is formed into ingots, the mill takes three samples. These are selected in such a manner that they will be truly representative of the entire melt. Billets are made from these samples and sent to the Ingersoll-Rand laboratories, where they undergo extensive metallurgical, chemical, and physical tests before the melt of steel from which they were taken is released for making into bar stock. Five samples from each of the three billets are hardened and then tested for grain size and hardening characteristics. The information obtained as a result of these 30 tests enables the laboratory to determine what sizes of bits can be made from that particular lot of steel. Two samples are analyzed chemically, tests being made for six elements, making twelve tests in all. From each of the three billets are forged 75 bits to ascertain whether the steel contains any physical imperfections that will detract from its workability. Thirty-six of these forgings are finished into bits, and each of these is given an actual drilling test in Barre granite. The most powerful drifters manufactured are used for this purpose, even in the case of the smaller sizes, as the bits are subjected to the severest possible service. All these investigations—153 individual tests—are made before the steel mill is permitted to complete the processing of any portion of the particular heat of steel from which the samples were taken.

The making of a Jackbit entails seventeen distinct and separate major operations, and some of these involve two or more steps. The first eight can be roughly classified as forging operations, and the last nine as finishing operations. It takes more than a month for a bit to pass through the plant.

The first operation consists of shearing the bar into sections, or slugs, of a size required to make a bit. A bar of a given diameter serves as the stock for bits of several sizes, and the length of the sheared section varies with the size of the bit to be formed. Every slug is visually inspected,

**DRILLING SIDE HOLE**

**If the bit has the water or air hole through the side instead of through the center, an additional drilling operation is required after the threads have been formed and the cutting edges milled. The hole is placed midway between two adjacent wings and is inclined toward the skirt end at a carefully determined angle.**

and is rejected if it exhibits any imperfections that would affect the quality of the forging to be made from it.

The cylindrical pieces of steel or slugs are next heated, preparatory to forging, in an oil-fired furnace the discharge end of which is a soaking pit in which the temperature is controlled so that the slugs will reach the hammers at the proper heat. From the furnace they pass immediately to the forging machines. It can be readily appreciated that, with an individual die for each of the many sizes and five types of Jackbits made, the investment in this equipment is large.

The forging goes from the die to a press that trims off the flash. The next step is the milling of the gauge to accurate dimensions. This is followed by annealing in an oil-fired furnace equipped with automatic temperature-control devices. There the forgings are heated and held at a specified temperature for several hours. This treatment refines the grain structure of the steel, relieves internal stresses imparted at the time of forging, and provides bits of uniform hardness for the subsequent machining operations. Before the slugs are ready for the finishing process it is necessary to remove the scale formed during forging and annealing. This is done in sand-blast machines from which the pieces emerge clean and smooth.

First among the finishing operations comes drilling and tapping on semiautomatic machines. This includes drilling the center hole for the passage of air or water, if the particular bit is of that type. Next, the cutting edges are accurately finished by milling them on semiautomatic machines. At this stage an extra operation is required in the case of side-hole bits—that of drilling the hole.

With the machining operations completed, all bits are washed in a metal-cleaning fluid to remove adhering oil. They are then placed in a continuous-type, electric hardening furnace of the most modern design. They travel through it on a belt the speed of which is varied with the size of the bit. At three points in the heating zone are installed pyrometers. These are connected with instruments that insure positive and close control of the temperature in each zone at all times. If for any reason the heat drops or rises beyond a certain limit, switches are automatically thrown and the furnace is shut down. These instruments also make a permanent record of the temperature in different sections of the furnace.

After the bits emerge from the hardening furnace they are placed on a special quenching fixture. As there is no delay in their handling, during which they might cool even a few degrees, there is definite assurance that all bits will receive the same treatment. While on the quenching fixture, the skirt, or upper part of each bit, is protected against contact with the cooling water. The time of quenching and the amount of water used vary with the size of the bit and the type, such as 4-point, 6-point, Carr, etc. At the proper instant, each bit is automatically removed from the fixture and falls into a vat of hot water that prevents it from cooling too rapidly.

From the hot water the bits go into one of two electric tempering furnaces where they are subjected to precisely controlled heat treatment. They remain there for a specified time while a blast of hot air is blown through them. Just before reaching the bits, the air travels over pyrometers that are connected to control instruments. Through the action of an electric eye the furnace is immediately shut down if the temperature varies more than 5° from that specified.

This careful, controlled heat treatment of the specially selected steel makes Jackbits superior for cutting rock to any bit that can be forged on conventional drill steel, and also insures that every Jackbit will be up to the standard set. The depth of hardening is great enough in most sizes to permit at least three regrindings in the field. In order to make certain that they are hardened uniformly and to the specified depth, bits of the different sizes are cut through and etched with acid at regular intervals and then checked with a standard one that has been similarly treated. At frequent fixed intervals, also, a finished bit is selected at random from the production stream and given an actual drilling test in Barre granite.

Following the completion of the heat treatment, Jackbits are again descaled. The final operation consists of rustproofing them by plating them. In addition to giving them resistance to corrosion, this treatment imparts a bright metallic finish that renders them readily visible. This is particularly important in underground mining operations because it not only reduces loss but also prevents the bits from being loaded into ore cars and subsequently getting into crushers, where they might do considerable damage. Jackbits are the only detachable bits on the market that have this plated finish.

Finished Jackbits are carefully inspected for defects, are checked for gauge size, and are then packed for shipment.

**TESTING**

**Before the steel from which Jackbits are made is approved for rolling into bars at the steel mill, sample billets are given a series of tests, including the making of a specified number of bits of which 36 are tried out in Barre granite. At certain intervals, also, a bit is taken at random from the shop production stream and its drilling performance checked. Powerful drifter drills are used for both of these tests, even in the case of the smaller bits, so as to subject them to the severest possible service.**

U. S. Bureau of Reclamation Photo

## TAYLOR PARK DAM

THIS structure on the Taylor River in western Colorado is now nearing completion by the U. S. Bureau of Reclamation. Its purpose is to provide supplemental irrigating water for the Uncompahgre Project which has been in operation for many years. The dam is of earth-fill construction, 168 feet high. The reservoir behind it will have a capacity of 114,000 acre-feet. Water is already being stored, and the dam will begin regulating the flow of the river in the coming spring.

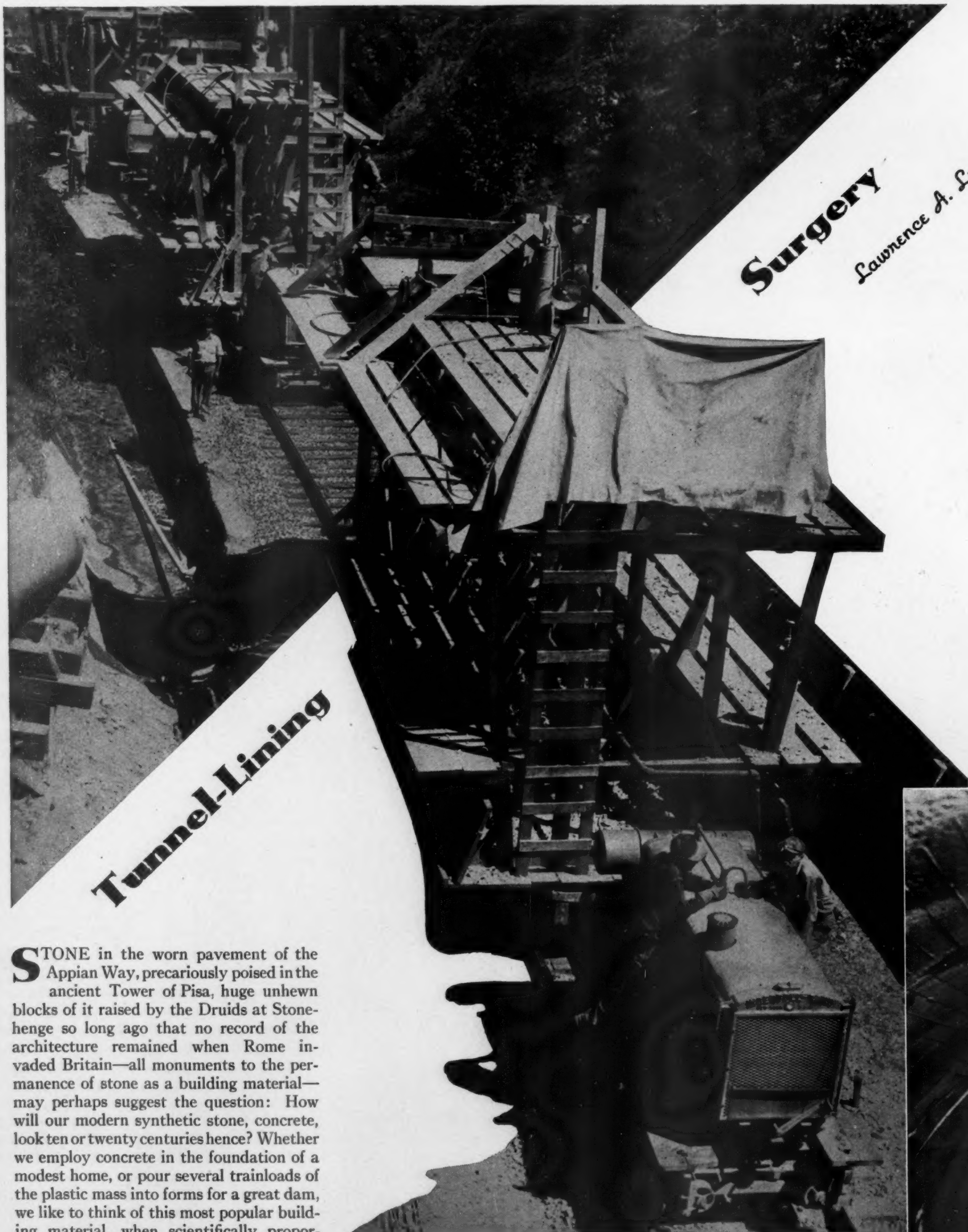
## WORLD'S HIGHEST BRIDGE

THE Royal Gorge Suspension Bridge, which spans the narrow chasm of the Arkansas River near Canon City, Colo., is 1,053 feet above the bed of the stream. It is 880 feet long between towers and 1,200 feet over-all. It has a width of only 18 feet, and is a highway toll bridge. The two main cables are each made up of 2,100 strands of No. 9 cold-drawn galvanized-steel wire, spun in parallel. To resist the action of the wind, the floor is tied at 20-foot intervals to 1½-inch galvanized-wire ropes moored to the canyon walls at points 100 or more feet below the structure and 100 feet on each side of the bridge line. The structure was designed and built by George E. Cole of Houston, Tex., and was opened to traffic in December, 1929. The Royal Gorge is a much-advertised scenic attraction. It is traversed by the Denver & Rio Grande Western Railroad, a short stretch of which is visible.

to.

# Tunnel-Lining Surgery

*Lawrence A. Luther*



OUTSIDE THE TUNNEL

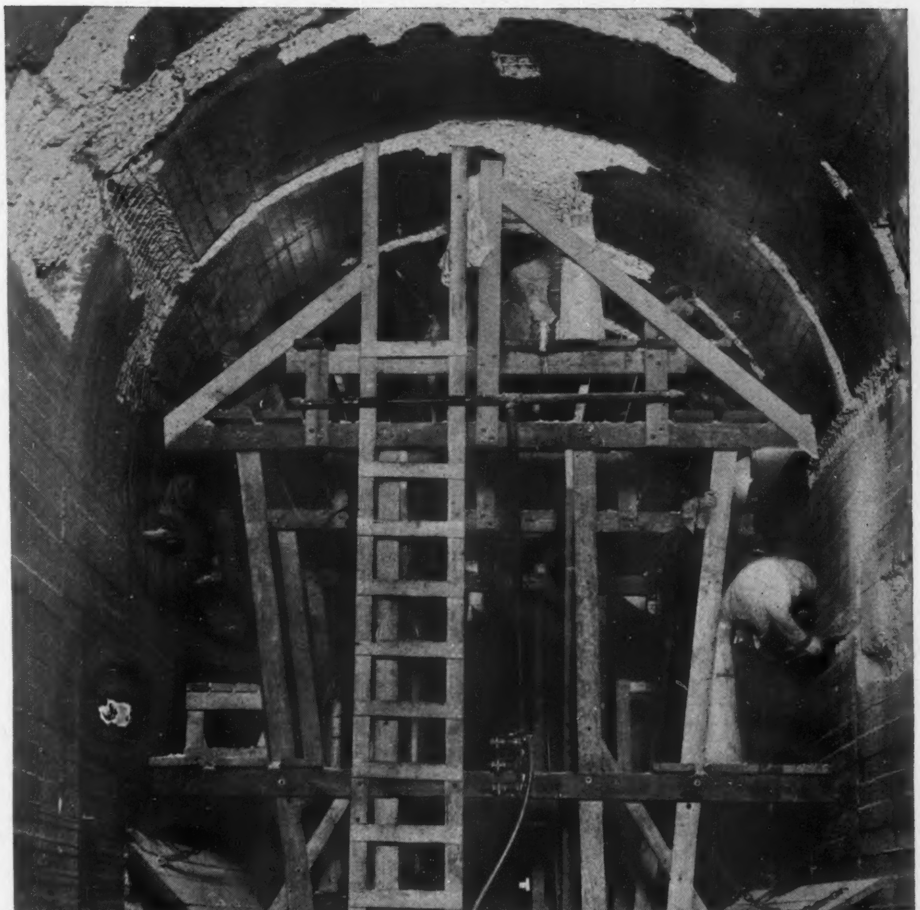
**Two self-propelled railroad-mounted compressors, each drawing two work cars, assembled near one of the portals. As many as six portable compressors of this type, with a total capacity of 1,320 cubic feet of air per minute, have been used by the contractor.**

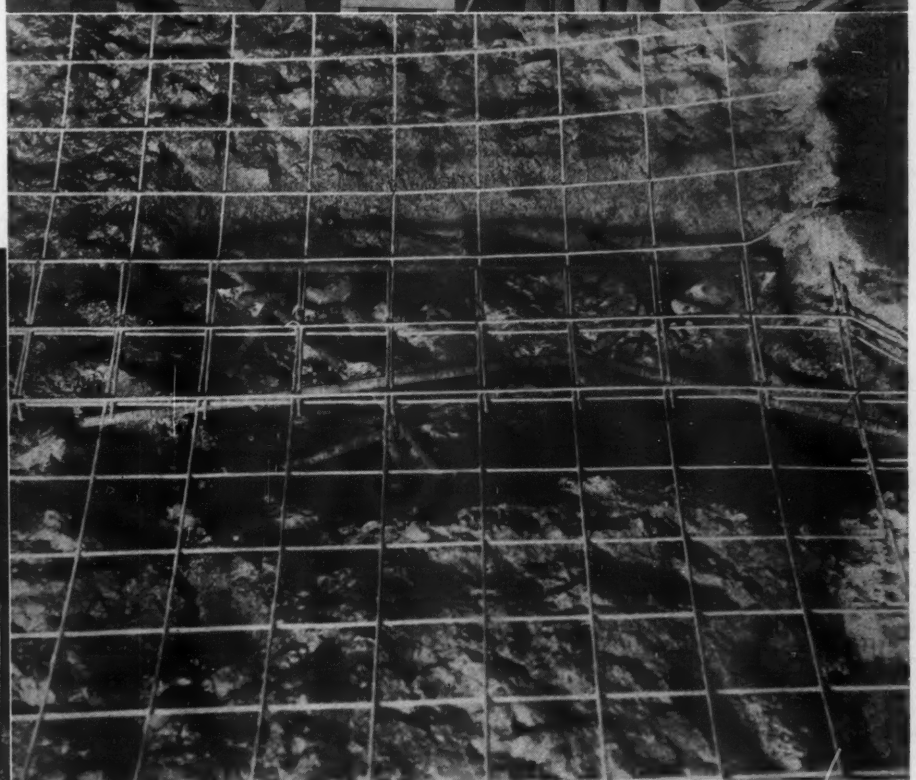
STONE in the worn pavement of the Appian Way, precariously poised in the ancient Tower of Pisa, huge unhewn blocks of it raised by the Druids at Stonehenge so long ago that no record of the architecture remained when Rome invaded Britain—all monuments to the permanence of stone as a building material—may perhaps suggest the question: How will our modern synthetic stone, concrete, look ten or twenty centuries hence? Whether we employ concrete in the foundation of a modest home, or pour several trainloads of the plastic mass into forms for a great dam, we like to think of this most popular building material, when scientifically proportioned, mixed, and placed, as the last word in permanence.

That this is only relatively true has become increasingly apparent to builders everywhere; and their concerted action,

spurred on by the important part played by concrete in virtually all the great structures in which so much public and private money is being invested, has resulted in the creation of specially equipped research laboratories and in investigation and experimentation by faculties of certain universities. Field and laboratory work has included analyses and photographic studies of many thousands of concrete samples and structures, and while particular attention has been given to the possible benefits to be derived from a better mixing, placing, and curing technique, findings everywhere have sustained the conclusions that the best of concrete is not invulnerable; that both the coarser and the finer aggregates generally used suffer little from deterioration; and that the elements formed in the cement by hydration are particularly susceptible to leaching out by water. Gases, acids, and frost have been assigned important but lesser roles by these experts, while water emerges as the chief offender because of its potentialities for damage the extent of which depends on the permeability of the structure, the quantity of the water, and the pressure with which the latter is able to attack the structure.

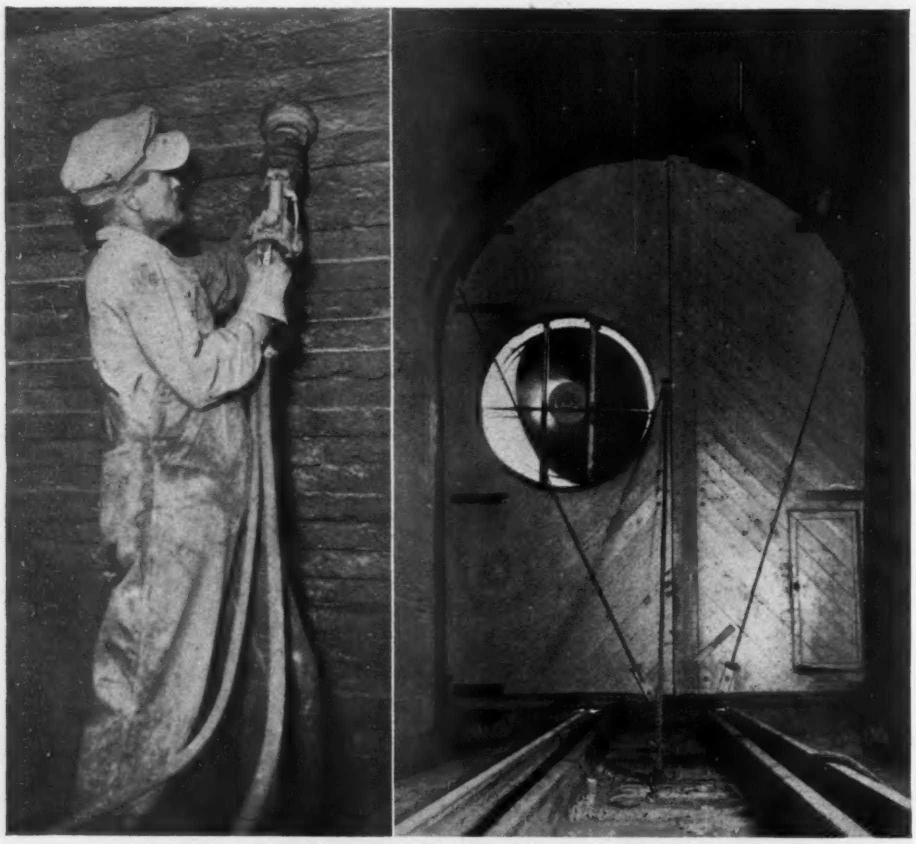
Concrete that has undergone impairment because of a lack of adequate protection may be observed in every class of construction from sidewalks to the largest of bridge piers and viaducts. In an era of increasing specialization, it is perhaps not surprising that the growing demand for the reconditioning of all kinds of concrete structures that have suffered deterioration or damage should produce specialists in concrete repair work. Such a concern is the Dur-ite Company, of Chicago. In this article we





**SEQUENCE OF OPERATIONS**

**Areas in which the concrete has disintegrated are chipped out to depths of from 2 to 8 inches, as may be required to reach sound material (top view). Where the cut is deep, holes are drilled for anchor bolts to which welded reinforcing bars are fastened, as shown just above. Steel mesh forms additional reinforcement. Gunite is then applied with air-operated cement guns (left) and the affected areas thus built up to their original thickness.**



**FINISHING OPERATION**

**After repairs have been made, the entire lining of the tunnel arch is sand-blasted and then given a final coating of a sealing and waterproofing compound. This is applied under pressure by introducing it through the arbors of a carborundum surfacing wheel used with a No.600 pneumatic grinder. At the right is shown a ventilating fan mounted in a bulkhead at one tunnel portal to keep the air moving inside.**

will outline the methods used by it in making extensive repairs to the lining of a tunnel in Franklin Canyon some 30 miles east of San Francisco and on the main line of the Atchison, Topeka & Santa Fe. This single-track tunnel is 5,600 feet long and pierces a spur of the Coast Range.

Driving of the Franklin Tunnel was begun in May, 1898, under contract. Headings were advanced from both ends, and heavy timbering was placed as driving progressed. The work was supervised for the San Francisco & San Joaquin Valley Railway by its chief engineer, W. B. Storey, Jr., later to become president of the Santa Fe System. The California Coast Range is, geologically speaking, extremely young and capricious and has unlimited surprises in store for tunnel drivers. Serious difficulties with swelling ground were experienced almost as soon as work on the bore got underway, and even though the talc through which it was being driven appeared to be stable, the floor heaved so that spreaders had to be used to brace vertical posts against inward movement. It became necessary to enlarge the tunnel section three times, and at some points as many as six complete sets of timbering had to be placed before the bore could be opened to traffic.

Several fires destroyed sections of the tunnel lining, and in 1907 and 1908 it was lined with concrete for a distance of 1,076 feet, the remaining stretch being completed in 1910. The tunnel now has a height of 20.6 feet from the base of the rail to the intrados of the arch, and the width at the top of the rail is 14.5 feet, increasing to 15.67 feet at the spring line 12.77 feet above the base of the rail. It has a concrete floor, with crushed rock ballast and center drain; is on a tangent throughout its length; and the lining ranges in thickness from 3.58 feet at the base to 3 feet at the spring line and 2.54 feet in the crown.

As water seepage became increasingly apparent, with surface indications of advanced disintegration especially in areas adjacent to both portals and in the west portal and wing walls, a detailed survey of the condition of the tunnel was made under the supervision of the Chief Engineer's Office in Los Angeles. But as this analysis of the concrete was only superficial, it was not surprising that the exploratory work, included in the program of repair, should disclose the fact that the unsound areas were deeper and more extensive than they outwardly appeared to be.

There were many long, horizontal cracks in the arch, with evidences of the same earth pressure and movement which had complicated tunnel driving. The contour of the lining was designed to resist earth pressure from all directions; and in this connection it may be remarked that it is more advantageous in a case of this kind to repair and to solidify the concrete than it is to replace it. A great deal of honeycombed concrete, a condition showing that the aggregates used in the original mix lacked adequate bonding material, has been discovered in the arch, indicating, possibly, that the sections in which placement was most difficult received the least compact and homogeneous lining and reminding us that mechanically driven vibrators were not in general use at the time.

As many as six track-mounted compressor units have been employed in the repair work; but, for the sake of clarity, the operations will be described in sequence and as they were carried on for several months with three machines. The first step consists of exploring and chipping away the defective areas, and is done under the supervision of a superintendent and a foreman by men working with No. 400 pneumatic chippers on a double-decked platform car. The latter is provided with a special hose-outlet manifold that is supplied with air by a 210-cfm., 2-stage compressor of the Ingersoll-Rand type on a self-propelled, tie-tamper mounting which also furnishes the power for moving the car in and out of the tunnel and spotting it at the desired location.

While some of the disintegration of the concrete can undoubtedly be traced to engine fumes, the fact that the most serious damage has been found at the points of discharge of seepage channels bears out the theory that water has been chiefly responsible. Some of the areas chipped out extend over many square yards, while others are small and follow narrow and irregular lines. In breaking out the concrete no particular pattern is adhered to, except that certain concessions are made in order to provide effective anchorages for the reinforcing materials used. The depth to which chipping is carried varies with conditions, reaching as much as 8 inches and occasionally requiring the services of L54 paving breakers. The minimum depth, however, is 2 inches, because experience has proved that a 2-inch layer of rebuilt material is the thinnest that will assure a positive and permanent bond.

The contract with the Dur-ite Company specifies the use of a variety of reinforcing materials and different arrangements to effect firm anchorages. Anchor bolt holes are drilled with star drills in No. 400 chippers, and the reinforcing is tailored to fit each chipped-out area and is put in position from a small platform car that receives its air supply from the chipping car by way of a hose connection.

Perhaps an analogy might be established between the ingenious and varied methods employed by these concrete specialists and the technique of modern dentistry; but the former are able not only to remove and to replace portions affected by decay but to rejuvenate large areas. In effect, the specialists make use of the original aggregates

and fill the existing voids, which are attributed to poor placement or partial disintegration, with a fresh bonding material compounded so as to achieve maximum penetration.

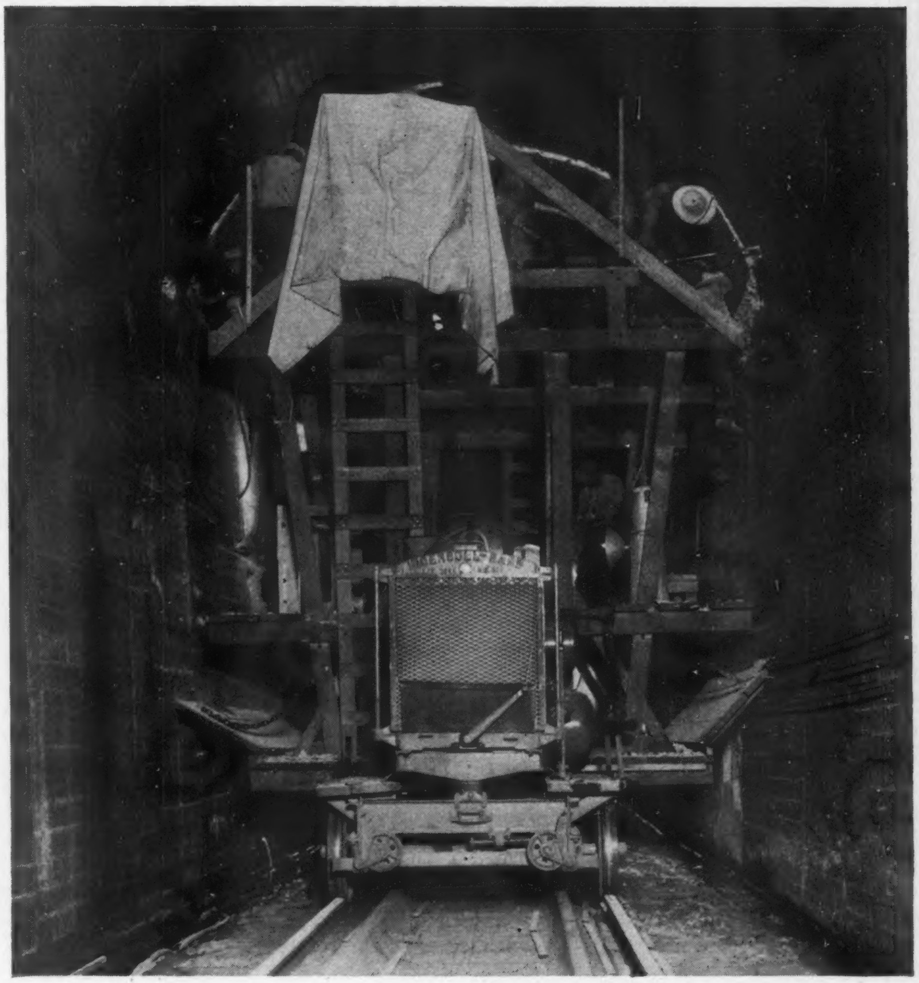
By the so-called Intrusion Process 1¾-inch holes are drilled in the tunnel lining to depths ranging from 6 to 14 inches with L87 Jackhamers using Jackbits, and expanding inserts are employed in injecting the patented compound from hose lines and under pressures ranging from 100 to 250 pounds—an air-driven reciprocating pump mounted on the work car periodically serving to boost the 110-pound pressure used.

The entire lining of the tunnel is treated with this intrusion material, the insert holes being spaced in accordance with the requirements of each area undergoing treatment. Pressure is maintained on several adjacent holes simultaneously, and rapid and extensive penetration, especially in porous sections in the arch, is attested by the discharge of the compound at points as much as 40 feet away from inserts under pressure.

To facilitate the removal of water where seepage is heavy, a few weep holes are drilled in the ground with an X59 Jackhamer. Where wet concrete indicates the presence of water under considerable pressure, holes are drilled and the intrusion process continued until a perfect seal has been effected. While this sealing operation is begun as soon as chipping is finished, it is continued wherever required regardless of the sequence in which the repair work is done; and in building up the chipped-out areas by the Gunite method, many holes which have been drilled for intrusion inserts are closed with wood plugs wound with paper so that they can be taken out and the holes used again.

Prior to its application with a pneumatic pressure gun, the intrusion compound is kept thoroughly mixed in a tank that is provided with air-driven propeller-type paddles. All this equipment is mounted on a double-deck work car hauled and supplied with air by a 160-cfm., track-mounted Type 40 compressor. The materials needed by a shift are transported to the working location in the tunnel on this car; and it is estimated that the total load moved up the 0.8 per cent grade from the east portal sometimes exceeds 10,000 pounds.

The rebuilding of the chipped-out areas is done with a cement gun using a conventional mixture of sharp sand, cement, and water, all surfaces being thoroughly wet down before the Gunite operation is started. The concrete is placed in the arch and side walls in successive layers of a thickness that will effect the best bond, and is screeded so that it will conform to the original contours of the lining. Air for this purpose is furnished by a self-propelled, 210-cfm., Type 40 compressor that has been used since its purchase in 1934 in tie-tamper service. The cement gun and accessories are mounted on a double-platform car similar to those employed for the other operations. The necessary materials for this work are hauled into the tunnel by a motor car and trailer from yards situated at both the east and west portals.



**WORK JUMBOS**

**The wooden framework mounted on a 315-cfm. compressor provides platforms from which the upper portions of the tunnel lining are accessible to workmen. The compressor supplies air for operating twelve or more chipping hammers. The work of removing the damaged concrete is done by No. 400 chippers, except on occasions when it is necessary to go down to the maximum depth of 8 inches. Then L54 pneumatic paving breakers are used.**

The entire arch lining is given a final surface treatment. This consists of cleaning it by sand-blasting and of applying a sealing and waterproofing compound under pressure with No. 600 grinders specially fitted with tubing to introduce the compound into and through the arbors of the carborundum surfacing wheels used. The grinding action does much, it is claimed, to bring about uniform penetration and the formation of an impervious surface having maximum resistance to both water and engine gases.

As this article goes to press, the contractor has in service compressor units with a total delivery of 1,320 cfm. These machines are being employed at scattered locations where the operations described are being duplicated. To lessen inconvenience from gases discharged by gasoline engines, their exhausts are piped into oil drums containing water, while rapid circulation of air throughout the bore is assured by a 600-rpm. ventilating fan mounted in one of a pair of hinged doors that serve as a bulkhead at the west portal. The fan is belt-driven from a gasoline engine mounted on the tunnel parapet.

Work in the tunnel was begun in July of 1937, and is still in progress. Sidetracks at the Station of Glen Fraser, close to the east portal, provide switching and car storage facilities, and the principal material yard and a camp also are located at this point. Some of the men employed are housed in portable barracks constructed of plywood, and a cooking and a mess tent are maintained by the contractor for the 40 to 55 men working one shift daily on the job.

A special effort is made by the operating officials of the Santa Fe to arrange traffic on the line so that train movement will delay the work as little as possible. It is estimated that, by the time the repairs on the tunnel lining are completed, there will have been used some 4,000 barrels of cement and 700 tons of sand and various compounds.

# Human Aquarium

COMPRESSED air makes it possible to do things that, to the man on the outside, seem like magic. A case in point is the so-called "human aquarium" that has been recently built in France after the plans of J. L. Breton, director of the French National Office of Research and Invention. Designed for testing submarine equipment, it is also to be used for giving exhibitions of divers at work, of fancy swimming underwater, and of marine life of all kinds.

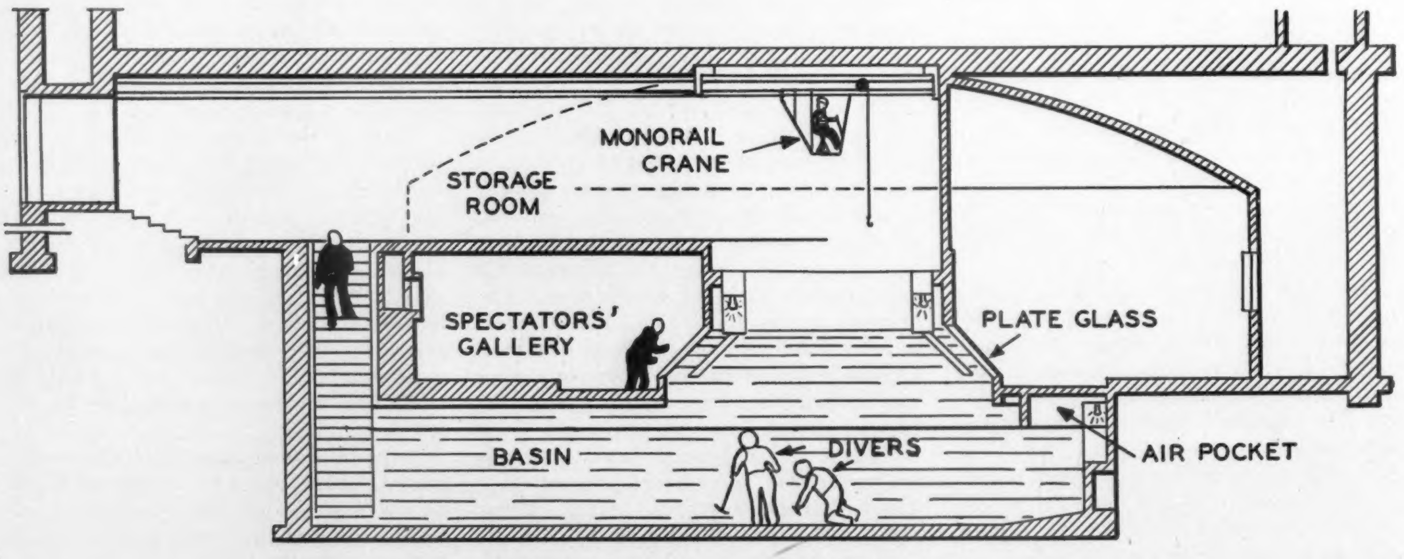
The structure is decidedly unique. It consists of a basin, approximately 40 feet in diameter and 15 feet deep, the upper part of which is in the shape of a truncated octagonal pyramid having a base about 25 feet in diameter and sides sloping 45°. The latter are made of plate glass, and offer an unobstructed view of the interior of the tank from the surrounding spectators' gallery. Immediately beneath the pyramidal section and built integrally with it is a pendant wall that extends down into the basin and forms an air pocket between it and the outer wall. This works on the same principle as the diving bell. As water flows into the tank and rises, the air trapped in this space is compressed, and when the air pressure and the water pressure are equal, the progress of the water is checked. This balance must of course be maintained; and this is done by admitting compressed air into the pocket as it is needed. Any excess air can be exhausted by way of a separate duct.

The lower edge of the pendant wall is 4 feet 3 inches from the floor of the basin, and swimmers, or divers and other submarine workers without breathing apparatus, simply by ducking under this wall and putting their heads in the air pocket can fill their lungs with oxygen. The unsuspecting visitor, however, will probably wonder how the men can remain submerged as long as they do without apparently breathing. A passageway and a flight of steps lead out of the tank from a point directly below the air space and into a room overhead where the necessary diving equipment and other paraphernalia are kept. To facilitate handling the heavier pieces, this compartment is provided with a monorail crane the outer rail end of which is attached to a revolving ring which permits spotting the crane over any part of the swimming tank.

For the comfort of the underwater workers or performers, the water is heated, after the basin has been filled, to a temperature of 77°F., and once that temperature is reached it does not take much heat to maintain it because the tank is underground. The heater consists of a series of coils in a tube nearly 10 feet long and 13¾ inches in diameter. In the cover of this tube are sixteen insulated coil connections which are joined in sets of two by eight U-shaped bars of steel. Each of these resistance bars is connected to a 5-kw. transformer which steps down the regular 220-volt current to 12 volts. By this arrangement all eight resistances or only as many of them as may be desired can be used to heat the water. Before passing on to the heating plant the water is purified with aluminum sulphate, soda, and chlorine and is run through sand filters for the removal of the solid impurities. A 6-hp. pump, with a capacity of approximately 185 gpm., delivers the water to the heater which, together with the filtering plant, is located underneath the tank.

An elaborate system of lighting has been installed, and this makes it possible not only brilliantly to illuminate every part of the basin but also to achieve beautiful color effects for exhibition purposes. There are 48 electric projectors, in four circuits, around the upper edge of the basin, and in the outer wall of the air pocket, likewise where they are beyond the reach of the water, is another series of projectors. These are for regular service. Each circuit also has a white, a green, a red, and a blue projector; and a special rainbow system, through the medium of motor-driven dimmers, permits the several circuits of colored lights to be turned on and off successively to give all possible color combinations. In addition, there is what is known as Wood's light by which certain submerged objects can be made luminescent.

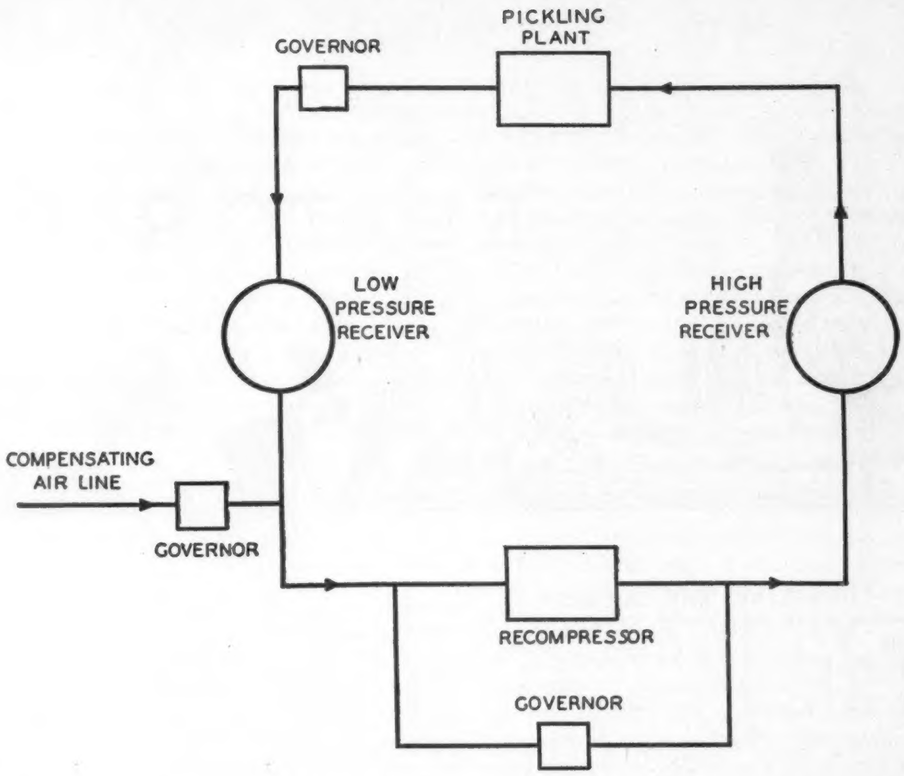
All the wiring is carried in a new fireproof cable, called Pyrotenax, in which the customary dielectrics such as rubber, paper, or asbestos are replaced by magnesia which is dehydrated and remains dry throughout the life of the cable. It is sheathed with solid-drawn tubing, and the insulating material is said to be so well protected against moisture that even when the exposed ends of a cable are immersed in water for several days it will not penetrate the insulation for more than a few inches. This is of importance in the case of the human aquarium where water in the electrical connections might lead to serious consequences. Every part of the structure, including the men underwater, can be reached by telephone from a control desk; and by the aid of loud speakers in the spectators' gallery the audience is kept informed of what is going on in the basin.




TEST AND EXHIBITION TANK

Cross-sectional drawing of the aquarium showing the various structural features in relation to one another. The performers can enter the tank almost without having to stop breathing, and once in the basin can fill their lungs with oxygen as often as they wish by putting their heads in the air pocket surrounding the tank. The water is prevented from entering this space by admitting compressed air until the air pressure and the water pressure are equal.

# Air-Operated Pickling Plant




LAYOUT OF PICKLING PLANT

WHAT is described as a white pickling plant with all the advantages and none of the drawbacks of both electrically operated and steam plants has been especially designed for a German tin-plate rolling mill, where it is now operating with complete satisfaction, according to reports. Electric pickling is generally used in that country for the reason that it costs less than steam pickling, while the latter, despite the cumbersomeness of the installation, is preferred in Great Britain and in the United States because it results in better work.

The new plant is of the tower type and is operated with compressed air which, because of its adaptability, lends itself well to this service. It consists of a pickling vat, a washing trough, and a turntable, which facilitates handling the sheets on their way to and from the pickling room. These units are grouped around a pneumatic lift provided with a crosshead having three arms from each of which a basket can be suspended.

Operation is continuous, and as two of the baskets are being plunged up and down in the acid bath and washing trough, respectively, the third, containing finished work, is automatically released and placed on the table for emptying and reloading. With this done, the crosshead is raised and swung around sufficiently to bring the several baskets to their next positions in the cycle. As the crosshead rests on an air cushion it can be turned easily by hand. The other movements are controlled from a nearby station. The lifting mechanism or air cylinder is built in the foundation on which the entire plant rests and is reached by an underground passage that is constructed in such a way that no acid vapors can penetrate its walls. An exhaust fan keeps the air in the pickling room practically free from fumes.

The outstanding feature of the plant is the closed circuit on which it operates—the system by which the spent air is put back in the line and recompressed continuously. As the accompanying sketch of the layout shows, the compressed air, after it has done its work in the air cylinder, passes on to a low-pressure receiver. At that stage it is at a pressure of about 45 pounds per square inch. From there it goes to a recompressor which raises it to the required pressure of 90 pounds. Next it is delivered to a high-pressure receiver and then once more to the air cylinder, when the cycle is repeated. Any loss of air through leakage is compensated for by admitting compressed air from an outside source into the line by means of a loss-equalizing governor. This system of recompression results in a saving in power of 65 per cent!

Another advantage of the new plant is its flexibility. Compressed air, because of the ease with which it can be controlled, makes it possible to vary the height of the lift, the number of lifts in a given interval, and the force of the up-and-down movement or "jerk," as it is expressed, to meet the needs of the work. However, to prevent splashing the acid in all directions, there is a limit to the force with which the baskets can be plunged up and down, regardless of the power used. To offset this limitation, the pickling vat has been made especially deep.

Under actual service conditions, the air-operated plant has handled, it is claimed, more than 250 tons of metal in 24 hours. This output is based on a basket capacity of from 1,760 to 2,200 pounds and a lift ranging from 12 to 20 inches. The latter depends upon the thickness of the sheets being treated. Tests have proved that production can be considerably increased without sacrificing quality by speeding up the loading and unloading operations.

## Unwatering Pipe Lines With Compressed Air

MAINTENANCE men of water departments have their troubles, and one of them is the unwatering of pipe lines in making street connections. This job, though only a preparatory one, sometimes takes longer to do than the actual cutting in of the fitting. This is especially true in the case of piping of large diameter, of 12 inches and more. The Water Board of Danvers, Mass., which has done much to simplify maintenance work, has found an easy way of removing the water that remains in a pipe line after the shut-off is made, and here is how they go about it in that community. The method was conceived by Roger W. Esty, superintendent of the Danvers Water Board.

The water is forced out with compressed air and at a pressure generally not exceeding 40 pounds per square inch. This, it has been proved, can be applied with complete safety to the house service connections. The air is supplied by a portable compressor, which is ordinarily included in the equipment of such maintenance departments, and all that is required is to attach the air hose to a hydrant at the highest point in the section to be unwatered; to open a hydrant at the lowest point; and then to turn on the air. In this way it is possible not only to clear the line but also to divert the water so that it will not interfere with operations in the trench.

The biggest job of the kind so far attempted by the Danvers Water Board was the unwatering of a dead-end section for the purpose of cutting in a street tee and several gates on the main line and on hydrant branches. This section was approximately 6,000 feet long, and consisted of about 5,000 feet of 6-inch-diameter pipe and 1,000 feet of 8-inch pipe. It took only 35 minutes to empty the line of approximately 11,400 gallons of water.


### TUNNELING THE ROCKIES

YESTERDAY'S dreams are tomorrow's accomplishments. As with a magic wand, passing years transform the unusual into the commonplace. Proof that these assertions are true in the engineering world is abundantly found in such works as the Boulder Dam, the Colorado River Aqueduct, the Grand Coulee Dam, and other spectacular undertakings. Now the U. S. Bureau of Reclamation is about to reverse the flow of the upper reaches of the Colorado River—to turn it about and make it run eastward through a 13-mile tunnel that will pierce the Continental Divide.

Because of what has been done, nothing now seems impossible, and yet it is interesting to note that only 28 years ago a competent and far-seeing engineer was considered an impractical theorist because he proposed almost the identical scheme that Uncle Sam is now preparing to carry out. That dreamer, who didn't live to see his dream come true, was Fred A. Fair, a mining and civil engineer of Boulder, Colo.

Fair was a sort of Robin Hood of his profession, an engineering philanthropist who spread the seed of fruitful ideas that germinated and grew up in other people's orchards. At heart he was a prospector, which means that he was interested primarily in delving not only in the earth's crust but also in the far richer realm of ideas. The actual putting of the ideas into effect had only a passing appeal for him: he was always chafing to get on to the next of the many images that passed across his fertile mind. Being such a rolling stone, he gathered little material moss; but that mattered not at all to one of such a nature.

It is impossible to say just when Fair conceived the notion of bringing water through the Rockies, but he made a survey for a tunnel in 1910. This bore was to be about 9 miles long. Its western portal was to be located on the Colorado River—then the Grand—near Granby, about where the main collecting reservoir of the Colorado-Big Thompson Project will be. It was to emerge on the eastern slope just east of the mining camp of Ward, some 10 miles south of the east-portal site of the current scheme. The water was then to be run by gravity into Gold Lake, which was to serve as a balancing reservoir. From there it was to be piped to a point just east of Rowena, whence a pressure penstock and pipe line was to direct it to a hydro-electric generating plant to be built on Left Hand Creek. The turbines would have been under an operating head of approximately 1,800 feet. After passing through the plant, the water was to be stored and then distributed to the farmlands below for irrigation.

Construction work was actually started under the name of the Boston-Colorado Power Company; but it was stopped by reason of financial difficulties after five dams had been partly built and a great deal of money had been spent on property and rights of way. After work was brought to a halt, Fair attempted to interest new capital, and made several trips to New York for that purpose; but those before whom he laid his plan called it too visionary. Now the Government engineers consider a similar project so thoroughly sound that they believe its annual benefits to farmers will amount to nearly one-fifth of the total cost of the irrigation features.

Although Fair's brain child never lived, it is indirectly the means by which his name will probably always be identified with the high country that he came to know intimately while conducting engineering investigations to determine the best line along which to drive a tunnel. Climbing about the forbidding heights, he discovered two small glaciers, to which he afterwards led parties of scientists and naturalists. One of these ice sheets was named Fair Glacier and the other one Isabel Glacier, in honor of Mrs. Fair. In the same area there is an almost inaccessible chasm to which mountaineers have given the austere title of Hell Hole. It is guarded by jagged and lofty spires, and few persons have ever set foot in it. After Col. Charles A. Lindbergh electrified the world by flying the Atlantic Ocean alone, Fair suggested that this wild and unconquerable region typified the dauntless spirit of the famous aviator and proposed that the highest and most precipitous of the peaks be named for the Lone Eagle. Immediate sanction was given the idea, and the imposing natural bastion is now officially known as Lindbergh Peak.

### SIRE OF 'QUODDY DIES

ANOTHER and a more famous dreamer died last month. He was Dexter P. Cooper, father of the ill-starred Passamaquoddy Tidal Power Project. Illness sent Cooper to the Passamaquoddy Bay area at the eastern tip of Maine in 1919, and as he watched the relentless tides sweep in and out, he dreamed of harnessing their enormous latent power. In 1935 he prevailed upon the Government to start the construction of a series of dams designed to capture the inrushing water for delivery later to turbines that were to turn electric generators. The flaw in all tidal-power schemes—they can operate only intermittently—was to have been overcome by pumping water to a high-level reservoir and by releasing it during the lag between successive tides.

Cooper's plan was concededly visionary. In fact, one of the Army Engineers in charge of the work stated openly that it would be less costly to generate power at the same point by steam, even if it were necessary to ship in coal to burn under the boilers. Nevertheless, many hard-headed engineers believe that the 'Quoddy Project would be worth its cost as a laboratory in which to discover an economic method of developing power from tidal action.

On such grounds, Cooper's dream perhaps deserved a better reception. As the *New York Times* points out, "It is out of such dreams, many of them once denounced as impracticable, that the civilization of America has come. The tides of 'Quoddy will long be a moving monument to Dexter P. Cooper. Some day they may be put to work."

# This and That

**Making Water Wetter**

Water can perhaps not be made wetter, but at least it can be treated so that it will better impart its wetness to substances of different kinds. Nature has given us the finest example of a nonwettable surface in the case of a duck's back. Some natural materials, of which wool is one, also will not readily absorb water. This complicates matters in the textile industry by making it difficult to wash wool. However, certain by-products in petroleum refining, known as sulphonic substances, serve to make cleaning solutions that are added to the washing water more penetrable, and they are therefore extensively employed for this purpose. By their use it is possible to produce softer woolen fabrics which can be colored more delicately. The petroleum industry has also helped the textile manufacturer by developing special highly refined white lubricants that will not discolor fabrics when they drip on them from processing machinery.

* * *

**Mammoth Soviet Building**

Russia has announced plans for the largest and tallest structure in the world, one that will rise 1,300 feet, or 52 feet higher than the Empire State Building in New York City. It will be called the Palace of the Soviets, and is designed as an outward expression of Russia's determination to do all things on a bigger scale than they are done in capitalistic countries. Standing upon one bank of the Moscow River in the city of that name, it will be crowned by a statue of Lenin, 328 feet tall. The building will weigh 650,000 tons. The foundation, containing 63,000 tons of concrete, has already been laid successfully despite the difficulties presented by a sea of underground mud at the site. On this concrete mat there have been placed 64 reinforced-concrete girders, each weighing 1,000 tons, which will carry the weight of the superstructure. A theater capable of seating 20,000 persons is to be a feature of the building.

* * *

**New Boring Scheme Advanced**

Miles I. Killmer, a New York construction engineer, has been granted a patent on a new accessory operation designed to simplify the driving of subaqueous tunnels by the compressed-air shield method. It is well known that silt and certain kinds of clay can be pushed aside by a shield, thereby eliminating the taking of material into the tunnel opening and its subsequent removal for disposal. Mr. Killmer proposes to drive all underwater tunnels through such favorable materials. Where the stream or sea bed is of more resisting ground—gravel or sand, for instance—he would first excavate a trench large enough to hold the projected tube, and then fill the opening with clay or silt. This idea was carried out successfully on a lesser scale in driving the subaqueous bores under the rivers in New York Harbor, save that no trenching was done. Because of irregularities in the river bottom along the routes of the projected tunnels, sections of them extended through open water. To provide the necessary cover, clay was moved to those points by barges and dumped on to the bottom; and through this filled-in material the shield was subsequently pushed.

* * *

**Oiling Rock Drills**

Although the rock drill is produced with the same care that is observed in making a watch—equal attention being paid to the precision of parts—it is frequently mishandled and neglected in service. Failure to lubricate it properly is one principal cause of trouble. Expansion of the exhaust air reduces the cylinder temperature to a low point, and this, together with the fact that the rock drill operates at high speed, is ample reason why it should be kept well oiled. At a recent meeting of the Institution of Mechanical Engineers, in London, S. F. Gimkey pointed out that manual lubrication of rock drills is unsatisfactory because it is intermittent at the best, wasteful, provides a possible means for dirt to enter the drill when oil plugs are lost, and requires frequent stoppages with consequent loss of drilling time. Fortunately, the air-line lubricator insures constant feeding of oil to essential drill parts, and may be considered an investment that will return its cost many times over in the form of better performance and longer life of drills.

* * *

**Artificial Diamonds at Last?**

The quest for synthetic gems continues to captivate the mind of man, and indications are that the formula that has been so long locked up in Nature's breast is nearer the investigator's grasp than ever before. Since 1915, Conway Robinson, working first with the General Electric Company and later with the Westinghouse interests, has been delving into the secrets of the element carbon. He recently announced that he has proved his theory that the carbon which we know is not the true element at all. On the contrary, pure carbon is a silvery white metal that conducts heat 20 per cent better than silver and electricity better than copper. Mr. Robinson has produced such carbon in a porous form, and he is convinced that it can be compressed into rods which can be drawn into wire as soon as suitable apparatus is built. In wire form the metal will have useful application in lamps, radios, X-ray bulbs, etc. While producing metallic carbon, Mr. Robinson obtained a certain carbon suboxide which is, he states, the source material of the diamond. By melting this in a special vacuum-type electric furnace and with a proper solvent, he is confident that he can manufacture large diamonds of gem quality. The small artificial diamonds made by Moissan came, Mr. Robinson believes, from this suboxide, and were no larger because only a very slight quantity of the suboxide was formed by the procedure followed. We are not told whether the cost of synthetic diamonds will be so great that they will not be able to compete with stones of Nature's making.

* * *

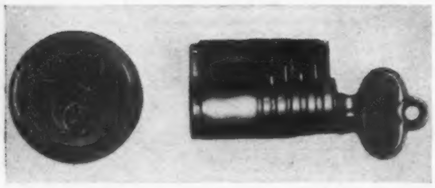
**Saplings for Steel Plants**

Although wood has not been used for fuel in American iron-working establishments for a great many years, the steel industry buys and utilizes annually approximately 20,000 elm, ash, oak, and hickory saplings. Poles from 16 to 20 feet long and from 3 to 4 inches in diameter at the large end are made from these for the purpose of stirring molten open-hearth and Bessemer steel. Violent boiling or agitation of the steel follows as a result of the chemical reaction set up between the carbon from the wood and the oxygen from the steel. The latter is thus mixed intimately with the layer of slag floating on top of it, and any excess carbon in the molten mass is absorbed by the slag.

* * *

**Steel-Eating Worms**

Although it sounds like a tall story, there are official documents to back up the report that there formerly existed in Germany a worm that thrived on a diet of steel rails. In 1887 a commission was appointed by the government to investigate a series of railroad accidents that had ostensibly been caused by this worm. That body not only confirmed the presence of the worm but reported that it had devoured 79.5 pounds of rails in two weeks. The worm was described as of gray color and about the thickness of the tine of a dinner fork. The creature was supposed to be able to soften the steel before eating it by spraying it with a corrosive solution secreted in two glands in its head. We are not told how the worms were stamped out; and, so far as American metallurgists are aware, they have never crossed the Atlantic Ocean.



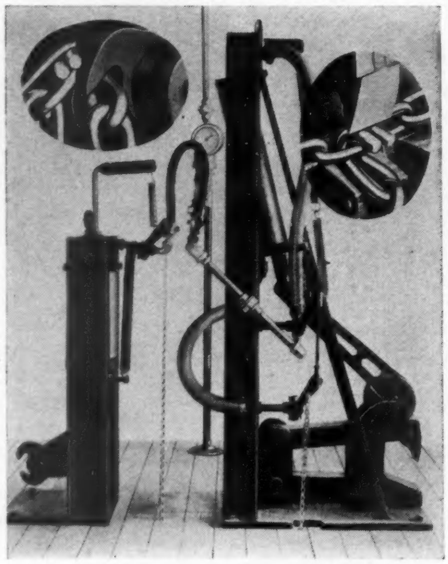
## Burglarproof Lock

BURGLARS take note! What was always believed to be impossible has been accomplished. A nonpickable lock has been invented, and by no other than a former detective of the New York Police Department, Samuel Segal. The new lock has been thoroughly tested by the Underwriters' Laboratories—the bureau of standards of insurance companies. According to their findings, the keyway cannot be picked by the insertion of any kind of foreign instrument: the cylinder is constructed so ingeniously that the lock can be opened only by its own key. Old locks can be made burglarproof, we are informed, simply by substituting the new for the existing type of cylinder.

## Pneumatic Machine Makes Quick Tire-Chain Repairs

WITH the season still at hand when tire chains may have to be dragged out, the Pyrene Manufacturing Company makes the announcement that it has developed a chain-repair machine that does in about twelve minutes what it takes an hour to do with hand tools. These figures apply to a truck. In the case of a passenger car the removal, rebuilding, and replacing of chains is said to go even faster.

The machine, as the accompanying illustration shows, is made up of two parts: the one on the left for opening chain hooks and the one on the right for closing them. They are mounted on a work bench and are operated with compressed air that can be taken from any line delivering approximately 7½ cfm. at a minimum pressure of 100 pounds per square inch. Pressure is applied to the opening and closing jaws through the medium of air cylinders which are controlled by 3-way valves which, in their turn, are opened and closed by foot pedals, leaving both hands free to handle the chains. Primarily designed for repairing truck tire



chains, the machine has been modified and can be set by a simple bolt adjustment to take any size cross chain hook.

## Commercial Possibilities of Tellurium

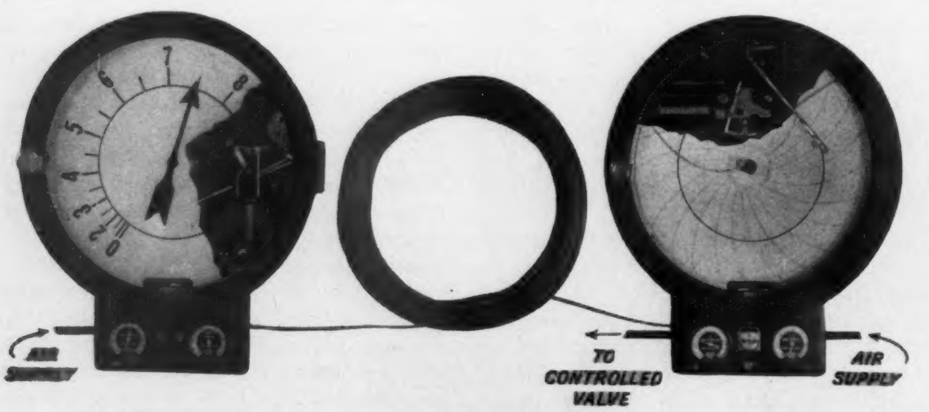
ONLY within the last decade, says *Metal Trade Notes*, have commercial applications been found for tellurium which, Webster tells us, is a rare element usually combined with other metals—with gold and silver in sylvanite, for example. For years, uses for tellurium were sought in vain, and it long remained an obnoxious element that plagued the metallurgist. It gave incompetent assayers an alibi for erroneous low reports on the gold content of ores and, because of the losses that were sometimes incurred in consequence, helped to spread the legends about "green gold," that elusive mineral that could not be trapped except by some secret process.

Today, tellurium serves to increase the resistance of rubber to heat, toughens it, and improves its aging qualities; lead stiffened by an almost imperceptible alloy addition of tellurium may find wide application in fields where the ordinary kind would be too weak; and tellurium-treated steel is just beginning to show commercial possibilities. Still other uses for it are predicted. It is therefore not unreasonable to suppose that this element, even though metal refineries are now discarding far more of it than they can market, will before long be mined on its own account.

## Pneumatic Transmitter and Recorder of Measurements

REMOTE measurement of process variables in atmospheres containing explosive gases where electrical measurement is not permissible is made possible by the use of a pneumatic transmission system developed by The Brown Instrument Company. It is something entirely new, and consists essentially of an indicating flow transmitter at the point of operation and of a recording and controlling flow receiver at the distant master control board, the two being connected by suitable tubing. The transmitting unit is a simple, balanced, mechanically operated air pilot built into an indicating instrument: the receiver is either an indicating or a recording pressure gauge calibrated in terms of the variables being measured. The complete assembly offers a safe and reliable means not only of transmitting measurement to a central station but also of recording it at the source. There is said to be nothing delicate or complicated about the system, the few working parts being simple in construction. In case of damage to the transmission line, repairs can be made without the need of special tools, and any shortening or lengthening of the tubing does not call for calibration or compensation.

According to the manufacturer, the system has the following characteristics, as determined by daily tests for nearly two years under actual service conditions: Receiver records less than one-fifth of 1 per cent change; balanced air pilot of transmitter stabilizes the mechanism so that it cannot overshoot; a 1 per cent change in metered value will be transmitted 200 feet in less than one second—full scale change in approximately 20 seconds; the element in the receiver develops a high pen torque in the case of small changes in transmitted pressures; readings are not affected by ordinary vibration at the transmitting or receiving end; ambient temperature change of 60° affects readings less than one-fourth of 1 per cent; operates dependably at subzero temperatures; and it consumes not more than 0.016 cubic feet of free air per minute.




TRANSMITTER. TUBING. RECEIVER.

# Industrial Notes

Laval University, Quebec, Canada, is adding a school of mines to its educational facilities. The building in which it is to be housed, and which is to be provided with a completely equipped laboratory, is now under construction.

Mr. W. W. Caldwell, until recently associated with the J. G. White Engineering Corporation, has become vice president and general manager of the building construction firm of Iglehart, Caldwell & Scott, Inc., 80 Broad street, New York City.

According to the American Iron and Steel Institute, the amount of steel now in use in the United States exceeds 1,000,000,000 tons, a record mark. This represents an average of 17,800 pounds per capita, or an increase of 15,200 pounds since 1900.

Plastics have invaded the printing field. According to the American Consul at Leipzig, Germany, a local printing plant has succeeded in making movable type from a plastic known as Polystrol. As compared with lead and zinc, formerly used for the purpose, the new material is not only lighter and noninjurious but can also be remelted and made to serve over and over again.

Taking cooling water for condensing purposes from a quarry is a novel procedure, but that will be done by the big new generating station at Bluffton of the Central Ohio Light & Power Company. To this end, the latter is driving a 370-foot tunnel through solid rock down into the quarry of the National Lime & Stone Company. This tunnel will be divided lengthwise by a wall, thus making it serve both as an intake and as an outlet for the cooling system.

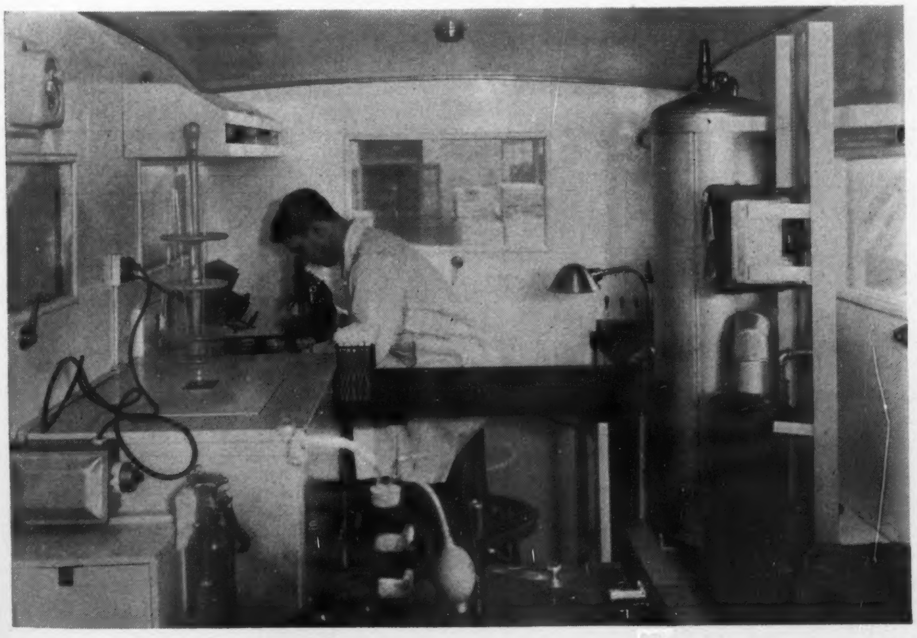
It is reported from Chile that the Instituto de Fomento Minero e Industrial de Antofagasta has recently put in operation there a plant that was designed especially for the treatment of low-grade copper oxide ores. The process of extraction was developed by an engineer of the Imperial Chemical Company, and by it the ore is reduced by means of sulphureted hydrogen to a sulphite containing from 48 to 60 per cent of fine copper. Running costs are said to be low, as only ½ hp. of electric energy is required to treat a ton of ore and all the sulphuric acid used is recovered. The plant has a capacity of 10 tons.

Spectacle wearers will be glad to hear that such a thing as an unbreakable lens has been perfected. It is made of a plastic material called Plexiglas and is offered under the name of Tulca. The new lens is cast in ophthalmic dies and is said to be approximately 60 per cent lighter than a glass of equal size and section and to transmit about 15 per cent more of the visible spectrum. It is inert to mineral, animal, and vegetable oils, as well as to hydrofluoric and hydrochloric acids; is proof against softening up to a temperature of 158°F.; and supports combustion slowly and only when exposed to an open flame.

An unusual feature of a lead-zinc mine in Yugoslavia, which is operated by an English company by the horizontal cut-and-fill method, is the floor of reinforced concrete that is poured on the stope floor after all the ore has been extracted. The layer of concrete is nearly 12 inches thick, and not only provides a good roof for the last stope mined on the level immediately below it but permits removal of nearly all the ore lying underneath the filled stopes. The cuts are 8.2 feet high and are started at the ore chutes, which are from 33 to 49.25 feet apart. There are one or more large raises in each stope for the introduction of filling, which consists of about 85 per cent finely broken schist quarried for the purpose and of 15 per cent waste sorted from the ore. The filling is spread by means of mechanical scrapers.

An apparatus that permits joints in pipe lines to be tested one by one as fast as they are made was displayed at the last Public Works, Roads, and Transport Exhibition held at Islington, England. It consists essentially of two rubber-tired disks or bulkheads. The disks, one on each side of the joint, fit loosely in the pipe and are held a few inches apart by set screws, the space between them being made watertight by inflating the tires. By means of a suitable connection, water under pressure is admitted to this annular space, the quantity in the case of a 52-inch-diameter pipe amounting to about 9 gallons. This is not much when compared with that needed when an entire main is filled to test the joints for tightness.

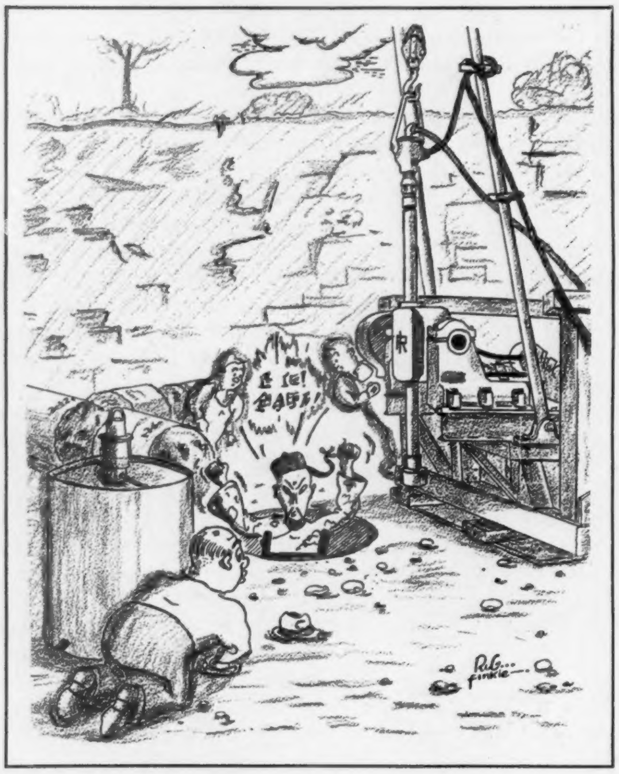
Sweden is engaged in the unusual task of constructing a gigantic chute for the floating of timber. It will connect an inland river with the sea, a distance of nearly 3 miles, and will consist of a canal 11,400 feet long and of a 3,900-foot conduit of reinforced concrete. The latter is being made up of sections, each approximately 21 feet long and weighing 6 tons, which are being manufactured by a special process in a plant built for the purpose. Though comparatively thin, tests have proved that the units will be equal to any strain to which they may be subjected in service. Incidentally, the chute has necessitated the construction throughout its course of no fewer than 57 bridges, including one railway and seven highway bridges, as well as a railroad for the transportation of the concrete sections. It is to be ready for the 1939 timber-floating season.



**AIR PRESSURE SUPPLIES ITS WATER**

**Interior of a truck-mounted, traveling laboratory maintained by the U. S. Department of Agriculture to give aid in the field to the country's cheese producers. The equipment is as complete as that of any small stationary laboratory. Hot and cold water, gas, and electricity are all available at built-in tables. The water supply is contained in the cylindrical tank at the right. It is equipped with a check valve such as is used on automobile tires, and through it compressed air is introduced into the space above the water, thereby maintaining the pressure necessary for supplying faucets. The air is obtained, as required, at automobile filling stations.**

# — Air Jets —



**Guess we're deep enough, boys!**

## *IT'S THE MINING GAME*

Bedrock, rigid granite, labyrinthine hills;
Scrape of pick and shovel; pounding of the drills;
Drip of copper water; spit of carbide lamp;
Hiss of air escaping; tap of powder tamp.

Grinding of the motors; closing of the gates;
Down grade cars a-jamming; thud of signal weights;
Timber hoists exhausting; dropping of the bars;
Stoppage of the motor; knock of banging cars.

Station calls a-buzzing; hammering of steel;
Chuck tender's vivid cussing; rhythmic turn of wheel;
Powder monkeys straining up the timbered stopes;
Narrow manways dripping stout manila ropes.

Miners in the crosscut; nippers rushing drills;
Timbermen a-sweating putting in the sills;
Ore cars on the turn sheet; muckers in the drift;
Someone on the lagging tapering off the shift.

What is there about it that we stay below?
Sweating, choking, cussing, asking "What's the show?"
Irishman and hunkie, Cousin Jack and Swede,
Men from every country, men of every breed.

Cramp of knotted muscle; copper-eaten back;
Splitting powder headache; cave-in down the track;
Man, we grin and bear it—curse it just the same;
And yet, somehow we like it. It's the mining game.

—M. K. Meisel

## *DEEPER!*

FROM THE LIGHT OPERA *MARY*

Way out West 'neath the burning sky,
Way out West where the oil fields lie,
Night and day you hear men cry:
"Deeper, let's dig her deeper!"
All day long you can hear the plink,
Plink, plink, plink of the drills that clink;
Clink as the black holes ever sink,
Deeper, for ever deeper.
And up and down as the sharp drills swing,
This is the song that the oilmen sing:

"Deeper, keep her going deeper,
Down, down, down into the ground!
Crashing through a thousand feet of soil,
Smashing walls that hide the inky oil!
We'll keep her, keep her going deeper,
Down for China we are bound!
There, maybe we'll lose the darned old drill,
But darn her! We'll go deeper still!"

Grim and mute, a sign of doom,
Stark and stare the derricks loom,
Gloomy guard of the oil-king's tune,
"Deeper, for ever deeper!"
Way down there in his murky bed,
Sound he sleeps for he thinks he's dead;
Sleeps till our drill taps his head,
Deeper, for ever deeper.
Then watch how he'll wake with an angry roar,
Roar as the oil men dig some more!

## *AIR AND THINGS*

There's something about
An air hose
That causes fascination;
The sandblast and the tampers,
The jackbits and the hammers,
The grinders—all have manners
Seductive to the eye

And yet, behold the
Stuff which feeds
The vibrating compressors;
They struggle, pound, and heave,
Sucking atmosphere to breathe,
And we wonder how they leave
Any breath for human lungs.

—G. M. Butts


**Here's a real test for that machine, Buddy!**